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Solar Thermal Power Systems Project
Parabolic Dish Systems Development

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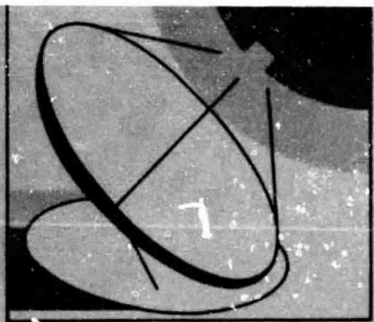
Test Results of an Organic Rankine-Cycle Power Module for a Small Community Solar Thermal Power Experiment

(Ford Aerospace and Communications Corporation)



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by

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SCSE REPORT NO. 023
April 23, 1982

SMALL COMMUNITY

SOLAR THERMAL POWER EXPERIMENT (SCSE)

TEST REPORTS:

POWER CONVERSION ASSEMBLY VERIFICATION TEST ON THE TBC AND ENERGY TRANSPORT SUBSYSTEM QUALIFICATION

CDRL NUMBER 34 AND MOD 14

Prepared for:

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ABSTRACT

Verification testing of the organic Rankine-cycle (ORC) power conversion assembly at the JPL Parabolic Dish Test Site, Edwards Air Force Base, California, was completed on March 26, 1982. Qualification testing of the electrical transport subsystem was also completed. Test objectives were to verify compatibility of all system elements with emphasis on control of the power conversion assembly, to evaluate the performance and efficiency of the components, and to validate operating procedures. The tests at the PDTS satisfied all these objectives. After 34 hours of power generation under a wide range of conditions, the net module efficiency (from sun to electricity out) exceeded 18% after accounting for all parasitic losses.

ACKNOWLEDGMENTS

The tests described in this document were conducted by the Ford Aerospace Test Team with support by the JPL personnel at the PDTS. The team consisted of:

Test Conductor/Control Engineer . . . D. G. Fulton

Test Planning and Set-Up. . . . . . . W. A. Conway
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Technician . . . . J. Huntly

PDTS support in specific areas was provided by R. M. Kramer (software), R. M. Taylor (accelerometer set-up and data), V. Fish (instrumentation and inverter), L. W. Conboy (RCIA) and D. T. Stewart (RCIA and data link).

Inputs to this report were supplied by D. G. Fulton (control subsystem and data plots), F. P. Boda (PCS) and D. B. Osborn (receiver). JPL inputs were used in the summary of the accelerometer results and toluene analysis.

The JPL Experiment Manager was Taras Kiceniuk. The JPL Site Manager at the PDTS was Terry Hagen. On-site support included Bill Nesmith, John Woodbury and Dennis Maciej.

LIST OF ABBREVIATIONS

AFB	Air Force Base
ATC	Aerothermochemical Laboratory (FACC Facility)
B-N	Barber-Nichols Engineering Co., Arvada, Colorado
C&I	Control and Instrumentation
CCIA	Central Control Interface Assembly
CRT	Cathode Ray Tube
EAFB	Edwards Air Force Base
EPROM	Erasable, Programmable Read Only Memory
ETS	Electrical (or Energy) Transport Subsystem
EU	Engineering Units
FACC	Ford Aerospace & Communications Corporation
JPL	Jet Propulsion Laboratory
MOP	Master Operational Program
MPC	Master Power Controller (includes central computer)
NBO	Newport Beach Operations (FACC)
ORC	Organic Rankine Cycle
PCA	Power Conversion Assembly (FACC Receiver & B-N PCS)
PCS	Power Conversion Subsystem (Turbine/Alternator/Pump, Heat Exchangers, etc.)
PDTS	Parabolic Dish Test Site
PFDR	Point Focus Distributed Receiver
PMA	Permanent Magnet Alternator
RAM	Random Access Memory
RCIA	Remote Control Interface Assembly (Includes computer for PCA control)

LIST OF ABBREVIATIONS (Continued)

ROP	Remote Operational Program
RTD	Resistance Temperature Detector
SCSE	Small Community Solar Power Experiment
TAP	Turbine/Alternator/Pump (part of PCS)
TBC	Test Bed Concentrator
TFR	Trouble/Failure Reports
TP	Test Procedure
UPS	Uninterruptible Power Supply

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SECTION 1

SUMMARY

1.1 GENERAL

The SCSE elements completed verification tests at the JPL Parabolic Dish Test Site (PDTS), Edwards Air Force Base, on March 26, 1982. This test series also included the Qualification Test of the electrical transport subsystem, i.e., the inverter and switchboard. These tests were conducted using the JPL Test Bed Concentrator (TBC) to provide the solar power; the concentration ratio was ~1000. The TBC (Dish No. 1) was modified to accommodate the SCSE hardware at the focal point by the use of a FACC designed and fabricated support ring, water-cooled sliding plate and water-cooled shield.

The equipment was operated over the complete range of conditions that were planned for this test series including: (1) all levels of insolation and cloud passages; (2) many start-ups and shutdowns; (3) various inverter input voltage settings (equivalent to turbine speed setting); (4) all control modes and parameters; and (5) other operating parameters such as supplying power to the grid.

A total of 33.6 hours of actual on-sun power generation was achieved, 13.9 hours in February and 19.7 hours in March. The basic test objective was to verify the compatibility of all elements of the SCSE system with emphasis on the control of the Power Conversion Assembly, i.e., the assembly that produced the electrical power from solar energy. Other objectives were to evaluate the performance and efficiency of the various components, validate operating procedures and data retrieval, and demonstrate qualification of the switchboard and inverter, including grid hook-up. The SCSE is the first of its kind to have automated "plant" control of all elements using a master power control computer and a local computer for control of each engine. Thus it was also an important objective to demonstrate the operation of the plant control scheme.

The tests at the PDTS were successful and satisfied all the major objectives of the program. Key results are summarized in Table 1-1. The performance and operating characteristics of all components have now been verified, including the receiver, the ORC engine/alternator, the electrical transport/conditioning subsystem and the plant control subsystem. These tests constituted the first demonstration of a truly automatic control for a PFDR solar plant; tests over the range of operating conditions demonstrated complete stability. For example, the fluid temperature at the receiver outlet was controlled to 750 ±5 degrees F despite short periods of solar insolation variations of over 2:1. Similarly, output voltage was normally held within a range of ±5V around the predetermined voltage setting in the inverter (usually ~500 Vdc). The automatic data measuring/recording system was also fully demonstrated, providing over 100 performance and diagnostic measurements per second for each test. Measured receiver efficiency was excellent (~94-96%) and close to predicted

TABLE 1-1. SUMMARY OF TEST ACCOMPLISHMENTS

- ~34 Hours of Power Generation Under a Wide Range of Conditions
- First Demonstration of Automated Plant Control System
- Proof of Control and Stability Even for Severe Transients
- Receiver Efficiency >95 Percent (Measuring at 980 W/m^2 Insolation)
- Organic Rankine Cycle (ORC) Engine-Generator Efficiency ~23 Percent
- Net Module Efficiency ≈19 Percent (From Sun to Electricity Out)
- Inverter Demonstrated Voltage (Load) Control Concept for a Single Module and a Simulated Second Module

values; the net module efficiency exceeded 18% after accounting for all parasitic power losses. Details of the performance are continued in Paragraphs 4.2 and 4.3.

Problems which resulted in a significant delay in testing occurred in only two cases. First, the control valve became inoperative due to contamination in the valve servo, requiring replacement with a spare unit. The other was a problem in the inverter for the power-to-grid mode. Modifications were made to the inverter to permit a successful test of grid synchronization, but further repairs to one circuit board will be necessary before the inverter will reliably perform its automatic switching function to the proper load. Basically, the problems that occurred were not too significant compared to the complexity of the system and the number of components.

1.2 TEST RUN SUMMARY

Table 1-2 lists information for each test run including the run duration, test conditions (concentrator area masked, solar conditions, and load bank or grid hook-up), and the purpose and test parameters. Problems experienced during the test run are also listed. The "Test Numbers" are the chronological listing of each engine operation. A new "Run Number" was given to each magnetic tape as it was initialized by the operator. These are different from the test numbers since weather conditions or other problems sometimes prevented an actual engine turn-on. A sample data plot and details of the events which took place on each run are presented in Appendix A.

The primary test parameters are listed in Table 1-3. A discussion of the effect of these parameters on the SCSE performance and operation is given in Paragraphs 3.5 and 4.2.

TABLE 1-2. PDTS TEST SUMMARY

Date (1982)	Test No.	Run No. (Tape No.)	Run Duration	Conditions	Purpose/Test Parameters/Problem Areas
Feb 8	1	3 (02082)	4 Min	• 25% Masking of TBC (75% of area available) • Power to load bank (Runs 3 thru 20)	1) Initial check-out 2) Receiver shell temp (RCSTP5)* drift, automatic shut-down after 1 min., restarted for a 4 min. cool-down.
Feb 11	2	5 (02111)	20 Min	• 25% Masking • Solar flux 700-900 W/m^2	1) Control system and component charts. 2) Automatic shut-down after 20 min. due to A/D calibration channel outside of limits. Control valve was inoperative after shutdown, requiring removal of valve and replacement of valve driver.
Feb 23	3	7 (02231)	5.3 Hr.	• 25% Masking • Early high clouds, then 40 min. cloud, followed by clear conditions	1) System response to door closure (simulated cloud passage) for 0.5, 1, 2, & 5 minutes. 2) Vary voltage level (inverter setting), and thus turbine speed. 3) Check speed control mode. 4) Response to 40 min. cloud (with ~50% insolation.) 5) Hot re-start after shut-down.
Feb 25 (AM)	4	8 (02251)	1.4 Hr.	• No masking of TBC (full area) for Runs 8 thru 17 • Clouds of varying intensity	1) Check operation in moderate to heavy cloud cover. 2) Early shutdown and restart due to clouds. 3) Run stopped after bad receiver outlet temp. sensor (RCOTTP)* detected.

*All instrumentation channels are defined in Appendix B.

TABLE 1-2. PDTS TEST SUMMARY (Continued)

Date (1982)	Test No.	Run No. (Tape No.)	Run Duration	Conditions	Purpose/Test Parameters/Problem Areas
Feb 25 (PM)	5	9 (02252)	2.7 Hr.	• No clouds, ~900 W/m^2	1) Check response to three 0.5 min. and two 1 min. door closures. 2) Check effect of modified control constants. 3) Evaluate effect of low fan speed.
Feb 26	6	11 (02261)	4.1 Hr.	• Thin clouds growing heavier during last part of run	1) Door closures of 1 min. 2) Check speed control mode during door closure of 5 minutes, with a hot restart. 3) Evaluate control constants.
Mar 2	7	12 (03021)	0.7 Hr.	• Heavy broken clouds with 5 min. clear intervals	1) Check operation during broken clouds. 2) Valve did not respond after normal shut-down, and required filter change.
Mar 3	8	13 (03031)	6.7 Hr.	• Clear with winds of 10-20 mph with gusts to 28 mph	1) Evaluate different periods of door closures. 2) Steady-state operations in mid-day (~2 Hr.) 3) Check speed control mode. 4) Simulate emergency shutdown, then hot restart. 5) Effect of fan speed for windy conditions.
Mar 4	9	14 (03041)	1.6 Hr.	• Clear day	1) Evaluate effect of inverter voltage setting (turbine speed) 2) RCIA dropout at end of test.

TABLE 1-2. PDTS TEST SUMMARY (Continued)

Date (1982)	Test No.	Run No. (Tape No.)	Run Duration	Conditions	Purpose/Test Parameters/Problem Areas
Mar 5	10	15 (03051)	1.3 Hr.	• Overcast, insolation 200-400 W/m^2	1) Determine minimum solar flux for operation. 2) Evaluate controls and multiple restarts.
Mar 12	11	16 (03121)	1.6 Hr.	• Mostly clear sky, ~920 W/m^2	1) Steady state operation into load bank. 2) Check mods to power and energy program including updated effective area.
Mar 18	12	17 (03181)	1.1 Hr.	• Full area of TBC (Runs 4 thru 17) • Series of small clouds, insolation ~920 W/m^2 during clear periods	1) Normal operation with scattered clouds. 2) Inverter dc contactor malfunction, but software controlled turbine speed without brake operation.
Mar 19 (AM)	13	18 (03191)	2.8 Hr.	• 50% masking of TBC • Clear sky, over 1000 W/m^2 at start	1) Low power, steady state run. 2) Evaluate low fan speed. 3) Evaluate inverter voltage setting (turbine speed). 4) Short period of high power to inverter using both power supply and turbine at 95% valve position (rapid cool-down mode).
Mar 19 (PM)	14	19 (03192)	0.4 Hr.	• 25% masking • Clear sky, 800 W/m^2	1) Check 25% masking conditions. 2) Evaluate effect of start-up with bypass valve closed (Runs 18 through 21).

TABLE 1-2. PDTS TEST SUMMARY (Continued)

Date (1982)	Test No.	Run No. (Tape No.)	Run Duration	Conditions	Purpose/Test Parameters/Problem Areas
Mar 22	15	20 (03221)	3.0 Hr.	• 25% masking • Flux 900 W/m^2 with some high clouds	1) Medium power, steady state run. 2) Evaluate high and low fan speed and voltage setting. 3) Use of power supply with PCA into load bank. 4) Temporary shutdown due to sensor malfunction, test continued after mods.
Mar 26	16	21 (03261)	0.6 Hr.	• Full area of TBC (no masking) • Flux ~900 W/m^2 until cloud-caused shutdown • Power to grid	1) Check out power-to-grid mode. 2) Inverter malfunction when "idle" condition reached. 3) MPC drop-out at end of test. 4) Inverter components accidently damaged during post-test checkout, requiring repair at Nova.
			Σ = 33.6 Hr.		

TABLE 1-3. TEST PARAMETERS

Parameter	Purpose
1. Masking of the concentrator, i.e., variation in the area of the reflective surface	• Vary the maximum solar power available to evaluate part load efficiency
2. Solar insolation	• Operation under real conditions
3. Transient power conditions due to sliding plate (door) closings or clouds	• Evaluate the stability and performance of control subsystem
4. Voltage level at input to inverter (equivalent to turbine speed)	• Evaluate engine performance vs. speed
5. Operate the unit in a pre-selected mode including simulated emergency shut-downs and hot restarts	• Check ability to operate properly under all conditions and modes
6. Normal, steady-state operation	• Evaluate component performance and efficiency (Computer Program "OPWEG", Reference 23)
7. Fan speed	• Determine trade-off between fan parasitic loss and PCS performance degradation
8. Inverter load (load bank or grid)	• Check all inverter options and ability to switch automatically to proper load

SECTION 2

INTRODUCTION

The Small Community Solar Thermal Power Experiment (SCSE) is part of the overall Parabolic Dish Development Program being managed by the Jet Propulsion Laboratory (JPL) for the Department of Energy. As prime contractor under Phase II of the SCSE Program (Contract No. 955637), the Ford Aerospace & Communications Corporation (FACC) is contracted to design, fabricate and test elements of a solar-electric power plant. The Phase II program* includes verification testing of a single module system at JPL's Parabolic Dish Test Site (PDTS) at Edwards Air Force Base, the subject of this report. The verification tests were conducted in accordance with the applicable FACC Test Plan and Test Procedure (References 2 and 3, respectively). Included in the PDTS tests were the qualification and compatibility of the switchboard, and the inverter in the grid-connected mode. This could not be done until the tests at the PDTS were conducted; the results are described in Paragraph 4.2.4.

This Section provides information on the test hardware, the test objectives and information on the applicable test procedures.

2.1 TEST CONFIGURATION AND TEST HISTORY

Figure 2-1 is a photograph of the TBC/PCA taken during operation. The Power Conversion Assembly or PCA is the equipment mounted at the focal area and consists of several components, the major ones being the FACC receiver and an organic-cycle engine built by Barber-Nichols. A cut-away view of the assembly is shown in Figure 2-2. The 'heart' of the engine is the turbine/alternator/pump (TAP) in which the turbine is direct-coupled to the permanent magnet alternator (PMA) built by Simmonds Precision, and to the main feed pump. The variable frequency (~2500 Hz) 3-phase ac power generated by the PMA is converted to dc by a rectifier (also made by Simmonds) mounted on the base structure of the concentrator. Hence it goes to a nearby switchboard and to an inverter which changes dc to 3-phase, 60-Hz power at 480V. This power was dissipated at the PDTS by a load bank or supplied to the local utility lines (grid). Control is achieved using a computer located in the Remote Control Interface Assembly (RCIA) for engine control, and by the computer in the Master Power Controller (MPC) for overall control, data logging, etc.

Figure 2-3 is a greatly simplified schematic of the test set-up. The heavy broken line shows the path of the working fluid, toluene. Omitted from this schematic is the regenerator and equipment such as boost pumps, plumbing, etc. The 'power module' identified at the lower left of the figure is the equipment shown in Figures 2-1 and 2-2. The rectifier is one of the "PCS Auxiliary Boxes" identified in the photo (Figure 2-1).

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*A review of the Phase II status at the end of 1981 is given in Reference 1. This reference also summarizes the SCSE design features, performance predictions and component test results.

FIGURE 2-1. PHOTOGRAPH OF PCA AND ELECTRICAL BOXES ON TBC NO. 1

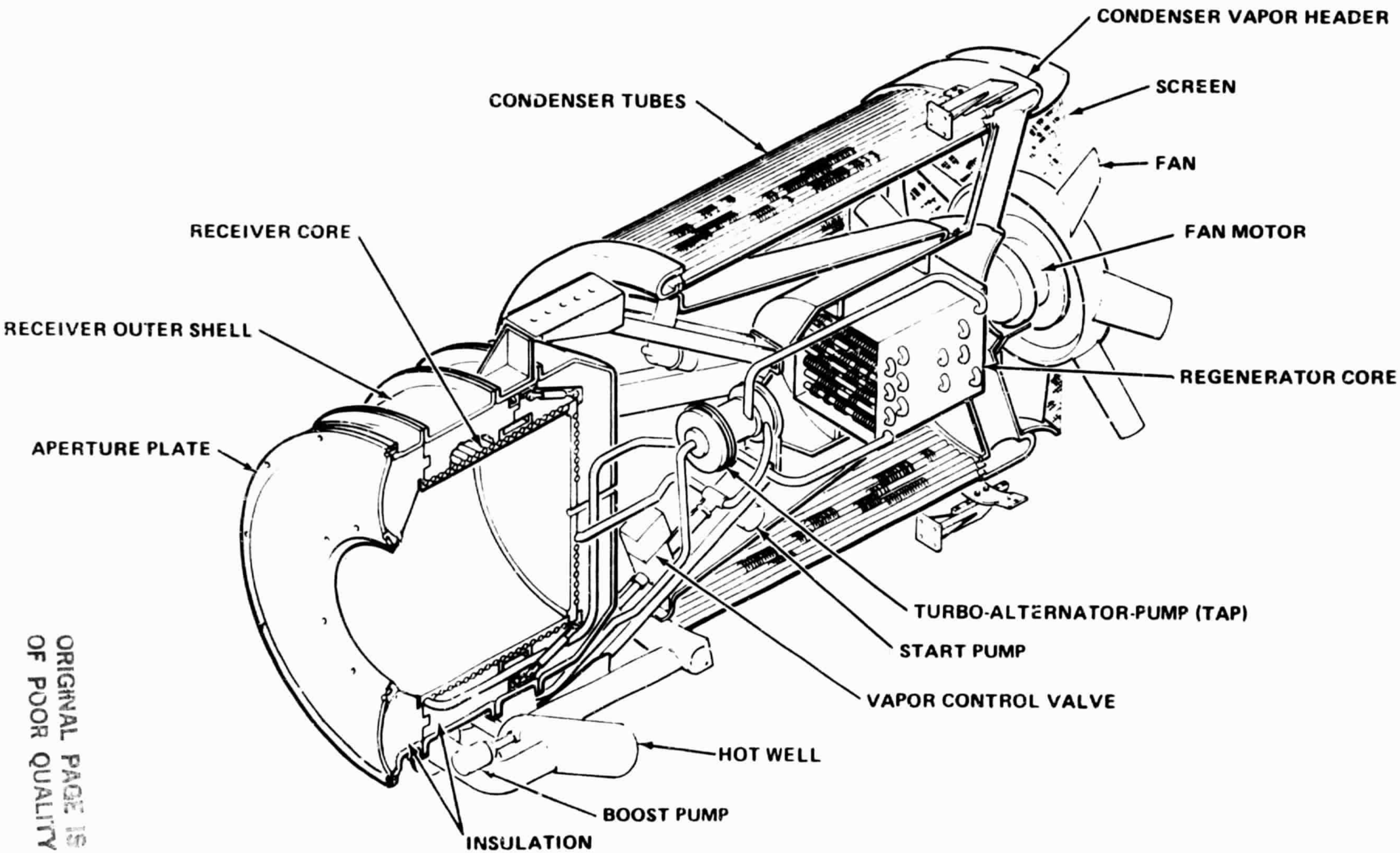

FIGURE 2-2. POWER CONVERSION ASSEMBLY (PCA)

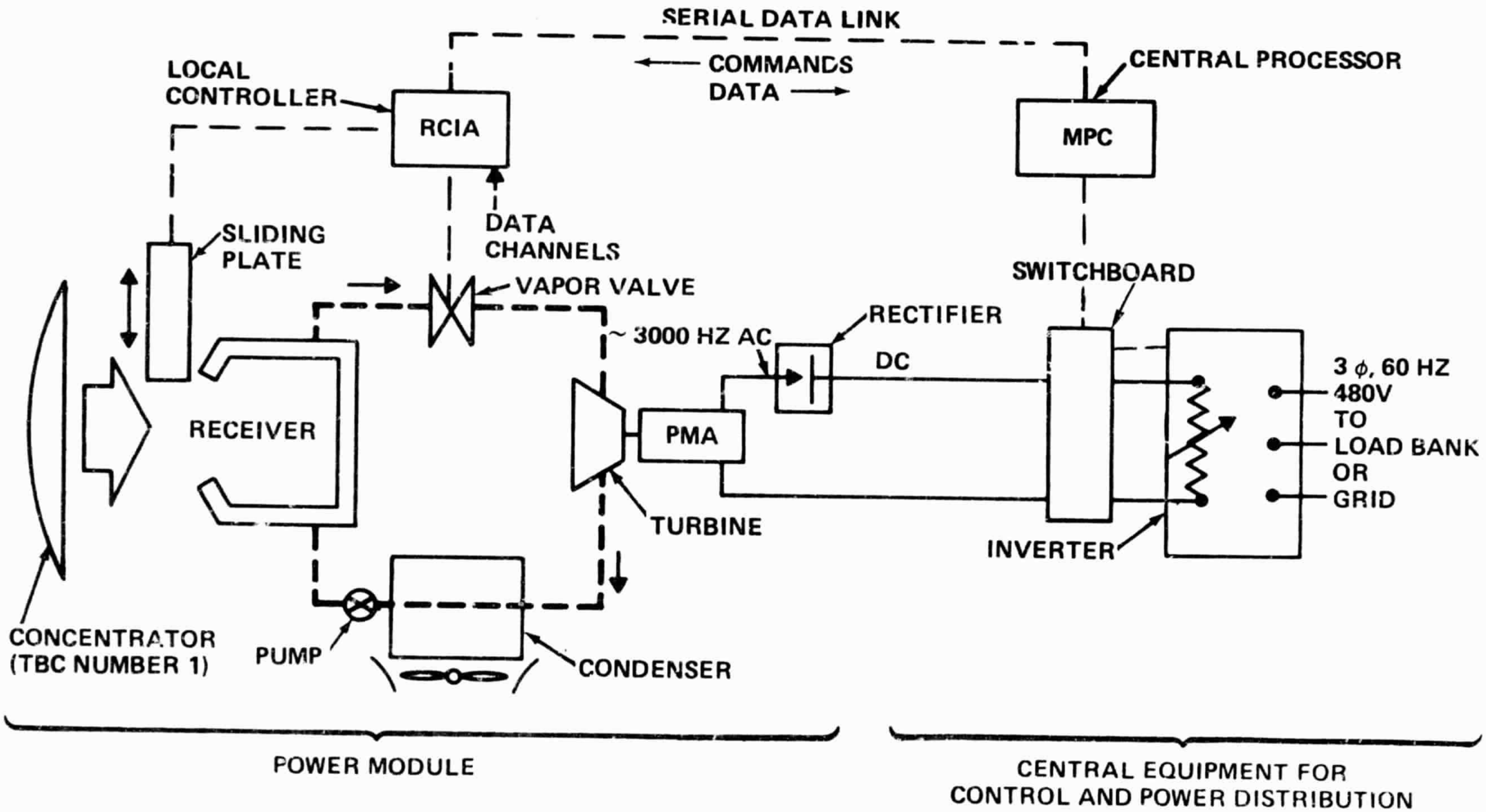

FIGURE 2-3. SIMPLIFIED SCHEMATIC OF PDTS EXPERIMENT HARDWARE

The receiver is a thick copper cylindrical shell with externally brazed stainless steel tubes in which toluene is vaporized. Primary engine/fluid control is achieved by using a vapor valve upstream from the single-stage impulse turbine.

Most of the PCA hardware that can be seen in the photograph (Figure 2-1) are rows of condenser tubing along the sides of the PCA and an electrically-driven fan at the topmost end. This is an air-cooled condenser, i.e., there is no secondary heat exchange fluid such as water in the system. A detailed description of the PCS is given in References 4 and 5.

Prior to solar testing the receiver underwent development and qualification testing at the FACC ATC laboratory. These tests used an electric resistance heater to simulate the solar input, and demonstrated the unique design features of the receiver -- the use of the thick copper shell for buffer storage, the 'forgiving' design which is not sensitive to variations in the flux distribution, high efficiency, no flow instabilities over a wide range of conditions, low pressure drop, etc. Details of these tests and the design features of the receiver are contained in References 6 through 9. Next, compatibility tests using the receiver, PCS and inverter were made in the ATC facility, again using the electric resistance heater to supply the input power. These tests were successful and all the components operated as planned using the load bank for power dissipation. Two key achievements of the compatibility tests were that the inverter provided the required preset level of voltage (load) control for the PCS, and that the computerized control subsystem was shown to be fully capable of controlling the engine in a safe, reliable manner. Results are reported in SCSE Report No. 22 (Reference 10).

2.2 TEST OBJECTIVES

The verification tests on the TBC had two general objectives:

- Verify operating characteristics of the elements of the SCSE single module system.
- Determine the compatibility of each interfacing subsystem/assembly.

The specific objectives to satisfy these are listed below and identified as "primary". Other desirable objectives are identified as "secondary".

2.2.1 PRIMARY OBJECTIVES

The primary objectives were to:

a. Verify that all PCA operational control modes were in accordance with SCSE system specification requirements,

b. Verify stable control of the engine/receiver,

c. Verify the power control approach; i.e., control of the dc input voltage at the preselected level by the inverter,

d. Determine the performance and efficiency of each element of the system (except the concentrator), such as the receiver, PCS, and inverter,

e. Determine output power as a function of incident solar flux and ambient conditions,

f. Verify that the electrical energy quality was within SCSE system specification requirements,

g. Determine system transient response during partially cloudy days,

h. Determine system characteristics/response to grid dropouts,

i. Determine the boundary contour for acceptable noise level (~85 dBA), and

j. Verify grid interface compatibility.

2.2.2 SECONDARY OBJECTIVES

The secondary objectives were to:

a. Validate operating procedures,

b. Gather data to assist in establishing maintenance requirements,

c. Gather data to contribute to a determination of degradation of PCA performance with time,

d. Gather failure rate and time-to-repair data,

e. Validate safety provisions and procedures,

f. Gather data necessary to determine variation of receiver performance with ambient conditions, and

g. Gather data relative to degradation of toluene quality.

2.3 TEST OBJECTIVE IMPLEMENTATION

The test objectives are relisted in Table 2-1. The first column to the right of the objectives indicates the relationship between the objectives and certain specification requirements of AS148588 (Reference 11). The other column lists whether the objective was completely satisfied by the tests reported in this document, or if further data are needed from the next test series. The table shows that most of the objections were achieved although additional tests are needed for some objectives, primarily those which relate to operating into the grid or which require extended test time. As a result of this test series, a number of modifications were identified which will improve the ease of maintenance (e.g., filter location and size), performance

TABLE 2-1. OBJECTIVE REQUIREMENT/MATRIX

Objectives	Spec.* Reqm't.	Was Objective Satisfied?/Comments
● Primary Objectives		
a. Operational Modes	3.2.1.3	Yes; safe, controllable operation for all modes.
b. Engine/Receiver Stable Control	--	Yes
c. Power Control; Rectifier/Inverter	--	Yes; dc voltage nominally held within ±5V.
d. Element Efficiency	3.2.1.1	Yes; see Paragraph 4.2.
e. Output Power vs. Insolation and Ambient Conditions	--	Yes; see typical data plots in this report.
f. Electrical Energy Quality	3.2.1.2	Partially; quality believed to be satisfactory but additional measurements needed for on-grid mode.
g. Transient Response	--	Yes; see typical data plots for clouds/door closings.
h. Response to Grid Dropouts	--	Partially using Nova power supply to inverter; additional tests needed.
i. Noise Level	3.2.5.14	Noise level low; measurements delayed until next test series.
j. Grid Interface Compatibility	--	Partially; one test performed as planned until idle condition reached, additional tests needed in next series.
● Secondary Objectives		
a. Validate Operating Procedures	--	Yes
b. Maintenance Requirements	--	Yes; key maintenance items identified.
c. Degradation of Performance	--	Partially; additional long-term tests needed.
d. Failure Rate and Time-to-Repair Data	--	Data obtained; additional test time needed.
e. Safety Provisions	--	Yes
f. Receiver Performance vs. Environmental Conditions	--	Yes; see Paragraph 4.2.2.
g. Degradation of Toluene Quality	--	Data obtained, see Paragraph 4.2.3.

*Refers to the System Specification (AS148588) requirement.

(nozzle block and feed pump design) or mean-time-between maintenance (bearing design and lubrication). These are planned to be implemented in the future.

2.4 TEST PROCEDURES

Detailed test procedures were written for the activities at the PDTS which were updated as the need arose. All PDTS procedures were approved by the JPL Edwards Safety Coordinator and the Site Manager for solar experiments. The documents that were used to implement the verification tests are listed below.

- TP-SCSE-006, Test Procedure - Installation of PCA on the TBC (Reference 12)
- TP-SCSE-018, Checklist - Toluene Drain, Fill and Dryout (Reference 13)
- TP-SCSE-020, Pre-Test, Startup and Shutdown Checklists for SCSE/TBC at PDTS (Reference 14)
- TP-SCSE-021, Test Procedure - Verification of SCSE Elements on the TBC at the PDTS (Reference 3)
- TBC Operation and Test Procedure (3 Feb 82) (JPL Document)

TP 020 was used for checking all the required steps to run an actual test, while the general test parameters were obtained from TP 021.

SECTION 3

TEST CONFIGURATION AND OPERATION

The Verification Tests were conducted at the JPL Edwards Test Station, North Base Road, Edwards Air Force Base, California. The solar experiments were located at the Parabolic Dish Test Site (PDTS) area of the JPL facility. JPL furnished, in addition to the test site, the following facilities or equipment:

- Test Bed Concentrator No. 1, associated equipment and personnel support
- SCSE control area in South end of Bldg. E-9
- Trailer No. 2 (Ford Trailer) which contained the following:
  - Switchboard
  - Nova Power Supply (used for inverter check-out)
  - Grid Interface Equipment (JPL-furnished)
  - Office and repair/storage area
- Space in North Trailer (Trailer No. 3) for locating SCSE software development equipment (Tektronix 8002A computer, CRT, printer, and PCA Simulator Box)
- Container for housing inverter and UPS
- Load bank
- Area in Bldg. E-69 to store shipping container and PCA when removed from TBC
- Conduits, J-Boxes, etc. for the electrical/C&I cables
- Tape recorder for accelerometer data

3.1 HARDWARE/COMPONENT LIST

The SCSE single-module equipment tested at the PDTS in February-March 1982 is defined by FACC Drawing Breakdown List (DBL) No. 2000810. The major elements in the system, the applicable drawing and the location at the PDTS are defined in Table 3-1. The key items in the test are underlined in the table and are the PCA and the inverter. The elements of the PCA are shown in Figure 2-2 and identified in Paragraph 2.1 (see Reference 3 for a detailed description of this hardware). The inverter design and fabrication was subcontracted by FACC to Nova Electric Mfg. Corp. of Nutley, N.J. This unit served not only to convert dc to grid-compatible, 3-phase, 480V ac power, but also as the load

TABLE 3-1. TEST HARDWARE AT PDTS

Item	FACC Dwg. No.	Supplier	Location
1. Top Assembly	2000810	Various	PDTS
2. Power Module	2000805	Various	On TBC No. 1
• TBC	(JPL HDW)	E-Systems/JPL	-
• PCA/SS Assy	2000772	FACC/B-N	Focal Area, TBC No. 1
• Water Cooled Shield and Sliding Plate	2000780, 2000774	FACC	Front of Focal Plane
• Mounting Ring & Insulation	2000773, 2000817	FACC	Focal Area
• RCIA & PCS Aux Box Assy	2000775	FACC	Base Structure of TBC
3. MPC/CCIA Assy	2000597	FACC	Bldg. E-9, South Rm.
4. UPS	2000831	NOVA	Shed south of Trailer No. 2
5. Inverter	2000765	NOVA	Shed south of Trailer No. 2
6. Load Bank	JPL (LB-30R)	JPL	Concrete pad south of inverter shed
7. Switchboard	2000766	Gould	In Trailer No. 2
8. Cables	2000790, -791, 2000792	Okonite, Belden	Various locations
9. Test Inst./Equip.		-	
• 8-Track Recorder	-	-	Bldg. E-9
• Spectrum Analyzer, Tape Recorder, etc.	-	-	Base of concentrator
• TV Camera	(JPL)	-	Apex of concentrator
• PCS Aux. Control Box	XFA-09-500	B-N	Base of TBC No. 1
10. Supporting Test Equipment*	-	Various	-
• Software Devel. Sys. (Tektronix 8002A, Printer, CRT)	-	Tektronix	Trailer No. 3
• Breadboard RCIA	2000507	FACC	Trailer No. 3

TABLE 3-1. TEST HARDWARE AT PDTS (Continued)

Item	FACC Dwg. No.	Supplier	Location
• Microterminal (keyboard)	2000769	FACC	Trailer No. 3 or at RCIA
• PCA Simulator	2000762	FACC	Trailer No. 3
• EPROM Programmer	-	-	Trailer No. 3
• Inverter Power Supply	-	Nova	Trailer No. 2
• Vacuum Pump	(JPL)	-	Trailer No. 2
• Misc. Handling Fixtures	-	FACC	Various

*Normally used for check-out and not in use during a sun-powered run.

(voltage) control* for the turbine/alternator/rectifier. The specification for the inverter is contained in FACC Specification AS147633 (Reference 15).

A brief description of other inportant components or subsystems in the experiment is given below.

Control Subsystem. Two computers perform the control and monitoring functions. A microprocessor in the RCIA controls each engine (one for the PDTS experiment). This digital unit performed data encoding for the PCS and receiver, PCA mode control, and control loop functions. A central minicomputer in the MPC provided overall control, communicated with the RCIA, and displayed/recorded data. A unit called the Central Control Interface Assembly (CCIA) provided the means of interfacing the MPC to external subsystems. Figure 3-1 is a block diagram of the single module system tested at the PDTS. Details of the control subsystem are contained in References 17 and 18.

Switchboard. The switchboard was located in Trailer 2 and performed the function of routing power to and from the various components such as PCA, inverter, UPS, load bank, and utility grid. It provided protective circuits, mimic lights to indicate which components were operating and breakers to isolate each electrical circuit. Sensors were provided in the switchboard to measure input (dc) voltage and current to the inverter; and the output (ac) voltage, current, and power factor. Specifications and typical circuits are contained in AS2000503 (Reference 19).

*Inverter operation is explained in TP SCSE-014 (Reference 16). As voltage increased - which corresponded to a power increase - the inverter increased its power output by increasing the SCR switching duty cycle, which reduced the inverter input resistance. This caused an increase in the inverter input current, resulting in a greater voltage drop across the alternator equivalent resistance. A drop in inverter input voltage (drop in turbine power output) produced the opposite effect.

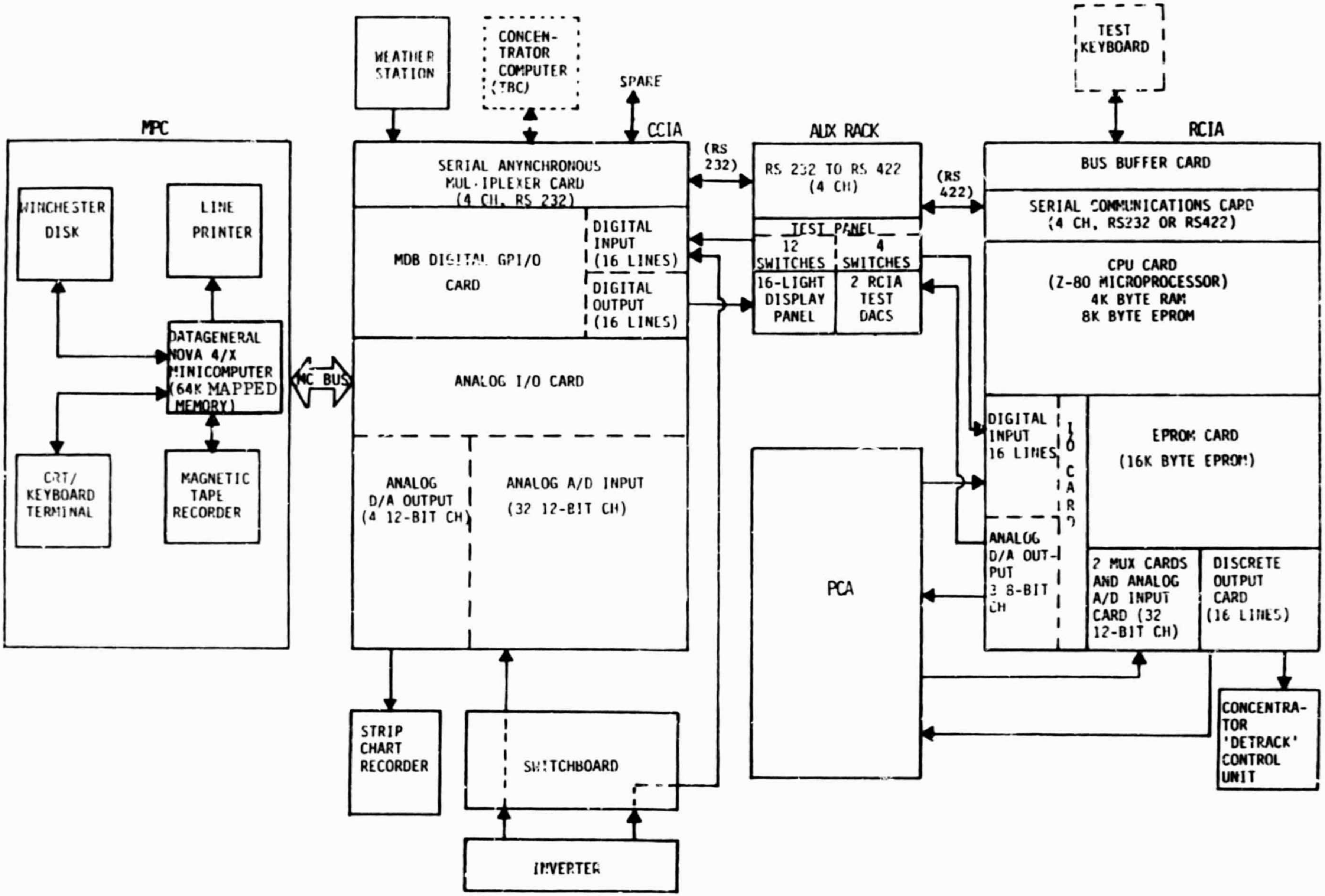

FIGURE 3-1. CONTROL SUBSYSTEM BLOCK DIAGRAM

UPS. The uninterruptible power supply was used to isolate sensitive items from grid transients or drop-out. Components operating on UPS power included the MPC, RCIA and PCA boost pump.

TBC Interface Hardware. Three items were fabricated to interface the PCA with the TBC and to protect it from the concentrated beam during sun acquisition/detrack or from sun walk-off. These were the steel mounting ring, the water-cooled aluminum shield and the water-cooled aluminum sliding plate. The design features of these items and other interfaces are described in SCSE Report 012 (Reference 20). A photograph of the PCA and interface hardware mounted on the TBC is shown in Figure 3-2. The PCA was supported by a structural cage which was bolted to the circular mounting ring. The rectangular water-cooled sliding plate covered the 15-inch diameter opening to the receiver during sun acquisition and during periods when the flux was not wanted, for example, during the simulation of a cloud passage. The large donut-shaped water-cooled shield protected against the remote possibility of sun walk-off, i.e., the inability to move the concentrator (see Reference 20).

3.2 WEIGHT BREAKDOWN

The weight of the SCSE equipment at the focal point was approximately 1437 pounds, not including the support cage. Table 3-2 tabulates the approximate weight of all the major items mounted in the focal area. The original PCA weight allocation of 1500 pounds was based on the limit for the GE Low Cost Concentrator (now PDC-1), for which the PCA was first designed to interface with. The SCSE components were well within the weight limit of the TBC, but the elevation drive still required some manual help (hand cranking) to get the concentrator through a problem area around 10° elevation angle.

TABLE 3-2. WEIGHT BREAKDOWN OF ITEMS MOUNTED AT TBC FOCUS

• PCA	~1437 lb.
Receiver - 516 lb.	
PCS - 921	
• Support Cage	155
• Mounting Ring	400
• Sliding Plate (Including Water)	129
• Shield (Including Water)	156
TOTAL FOR FACC ITEMS	~2277 lb.

3.3 TEST OPERATIONS

The conduct of the Verification Tests required a joint effort between JPL and FACC because JPL was responsible for operating the TBC, and FACC responsible for the SCSE equipment. The procedures and checklists used at the PDTS are listed in Paragraph 2.3. The detailed sequence of steps to be performed

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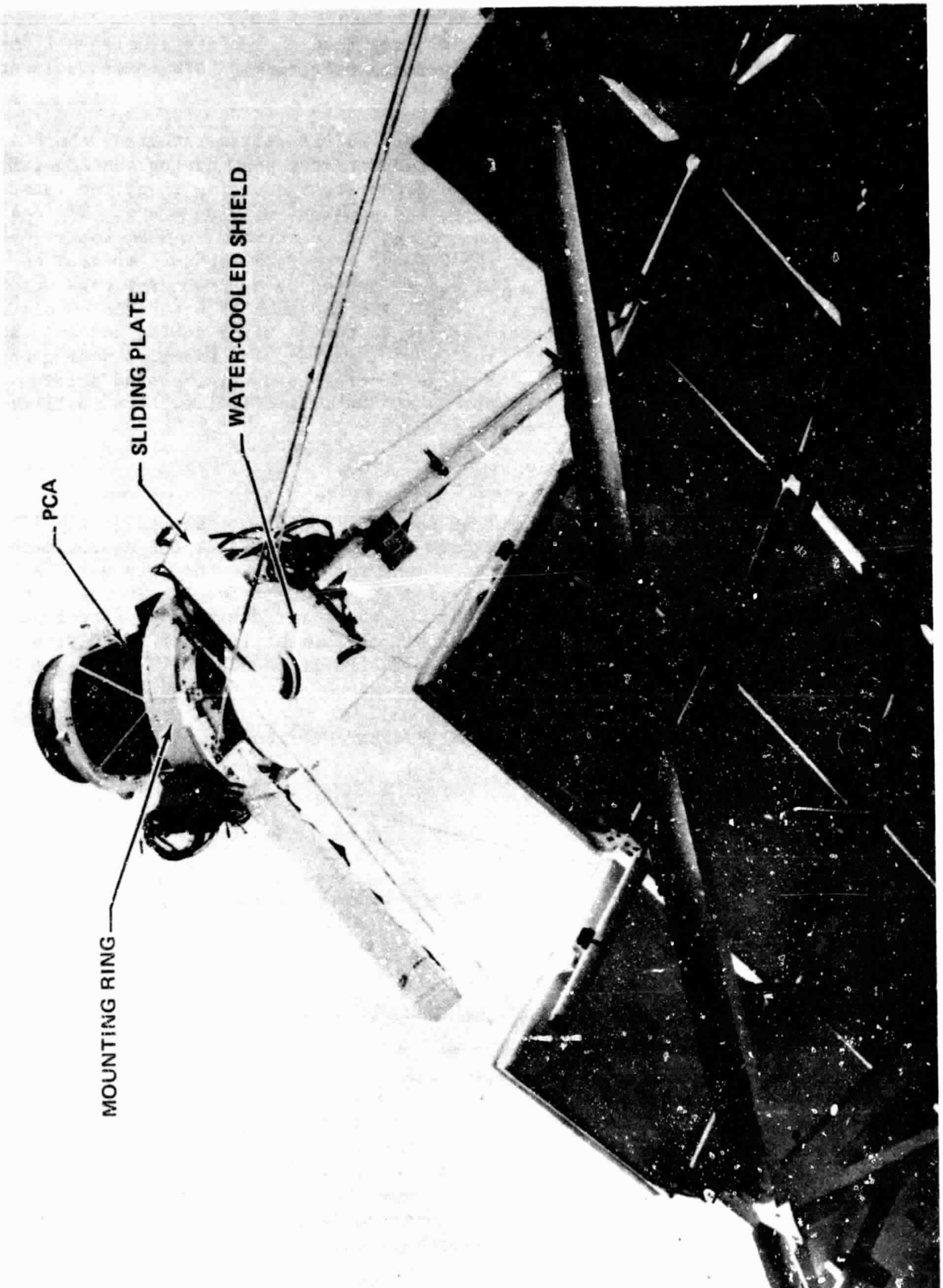

FIGURE 3-2. VIEW OF APERTURE END OF UNIT DURING OPERATION

for the SCSE equipment is contained in FACC Test Procedure (TP) SCSE-020 (Reference 14). The following list identifies the different checklists used for a test run:

- Test preparation
- Startup and Run
- Shutdown - Normal
- Shutdown - Emergency (used only if emergency condition existed)

A typical run would begin by bringing the MPC "UP" by setting the internal clock, initializing the tape and going through the prescribed system checks to verify the PCA and other subsystems were in order. The concentrator was proceeding through its checks at the same time. The function of the sliding plate was checked and left in the "REMOTE" mode so it could be closed by the computer in the RCIA if any serious fault occurred. The concentrator was then brought on-sun by rotation in azimuth in a clockwise direction looking down at the dish (the required elevation angle had previously been reached). As the sun was first acquired the plate was opened to help protect the mounting ring and water hoses from the beam, then closed as the sun spot moved across the plate to prevent the beam from reaching the open aperture. After the TBC sun tracker centered the beam at the proper location (as verified by viewing the TV monitor) and the appropriate items on the checklist were completed, the sliding plate was opened and the receiver began to heat up. The heat-up period before turbine start was approximately 4 to 5 minutes for the full mirror area and insolation of 900 W/m^2 or greater. Longer periods were required for less power input. Once the sliding plate was opened the startup sequence was entirely under computer control. The normal sequence during the start-up period was:

- When receiver shell temperature began rising, PCA MODE changed to POWERUP and pumps and fan started.
- The control valve opened slightly to relieve toluene pressure in the receiver when it reached ~675 psi. This cycling continued ("burping") to maintain a safe pressure.
- The turbine started when receiver shell temperature number 5 (RCSTP5) reached 680°F, or when turbine speed was greater than 5000 rpm and RCSTP5 was greater than 300°F.
- After turbine start, the flow was controlled to maintain RCSTP5 at a computed (changing) set point in order to allow the receiver outlet temperature to reach its normal operating value of 750°F. This set point started at about 580°F and increased as conditions changed. A period of 20 to 30 minutes or more was required to reach steady state receiver temperatures. An even longer period was required to stabilize regenerator and condenser conditions.

3.4 INSTRUMENTATION AND DATA RECORDING/PLAYBACK

The automatic data measuring/recording system in the MPC provided the performance and diagnostic measurements updated at one second intervals. These were recorded on magnetic tape from the time the tape was initialized until the time it was stopped, which generally occurred when the PCA had reached a safe shut-down point at the end of a run. Data could also be displayed on the CRT and printed out real-time. The CRT was one of the two ways of monitoring the data during a run (the other was an analog recording described below). The CRT display or printout was selectable from eight options summarized below.

Display or Printout No.	Title	Contents
1	Power and Energy (Program OPWEG output)	Power at 6 locations, component efficiency, energy at two locations
2	PCA Temps and Pressures	Temps and Pressures at 20 locations
3	Other PCA Measurements	20 Values for the receiver and PCS
4	PCA Events	List of discrete events, faults, and modes
5	ETS Data	Electrical data and inverter events
6	Weather Data	Information from JPL weather station
7	TBC Data	- - - - - Not Implemented - - - - -
8	PCS Performance Data	Selected data from Display 1, 2 and 3

Also each display had the same mode/status summary at the bottom of the screen. This summary display contained the following:

- PCA Mode (Examples: "NORMAL", "POWERDOWN", etc)
- ETS Mode (Power to load bank or utility)
- Link Status (Data link to RCIA and weather station)
- Measured Power out of the PCS (kW)
- Fault Status

The information contained on each display or printout is given in References 3 and 21. A complete sample data listing is contained in Appendix B.

The data system had the capacity for 114 channels of data. There were 11 spares and the available TBC channels were not implemented during these tests, leaving 93 channels of actual performance and diagnostic measurements.

Technical Report SCSE-027 (Ref. 22) lists the data which was transmitted on each analog and digital data link, and gives the appropriate identification codes.

The second way of monitoring performance during a run was by watching the 8-track strip chart recorder located next to the MPC CRT in Building E-9. Seven channels were selected to be displayed on the recorder for these tests:

- Valve command (TRVLPC)
- Valve position (TRVLP)
- Receiver outlet pressure (RCOTPR)
- Receiver shell temperature (RCSTP5)
- Receiver outlet temperature (RCOTTP)
- Turbine speed (TURPM)
- Local Eppley pyrheliometer reading (PM1 or PYRHL4)

These key measurements provided a good indication of the performance of the PCA and were used by the FACC Test Conductor as the primary means of realtime evaluation. Important events were noted on the chart along with the time of occurrence; this information was also written in the Log Book as part of the permanent record.

3.5 TEST PARAMETERS

The primary test parameters (variables) and their purpose are listed in Table 1-3 (Paragraph 1.2) as:

- Concentrator masking
- Solar insolation
- Transient input power (door closings or clouds)
- Inverter input (dc) voltage level

The following paragraphs identify the range or configuration of the primary parameters and summarize some of the operating characteristics that were noted during the tests.

3.5.1 CONCENTRATOR MASKING

The tests were started with 25 percent masking, that is, 25 percent of the area of the mirrors covered up (75 percent of the available solar power). The initial 25 percent masking pattern was provided by JPL and is shown in Figure 3-3. The outer row of mirrors and about 50 percent of the inner four rows were covered, leaving an unmasked region of about three rows deep. It was determined that the pattern shown in Figure 3-3 was not as desirable as the one derived by FACC (described below) because masking of all the outer mirrors produced an irregular and low level of flux on the back wall of the receiver. The pattern shown was used in Runs 3 through 7 (Test Nos. 1 through 3).

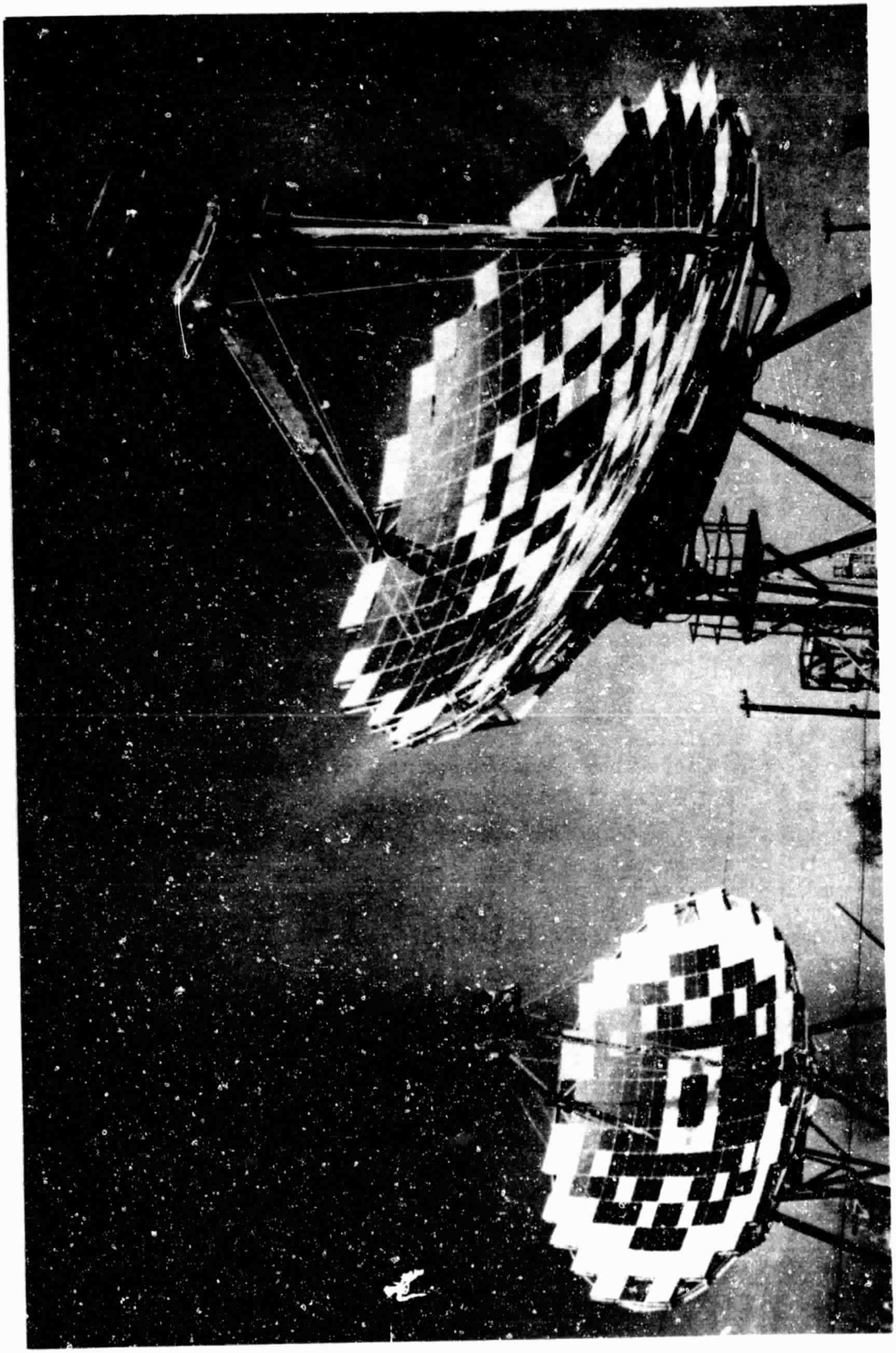

FIGURE 3-3. TBC-1 WITH THE ORIGINAL 25% MASKING PATTERN SHOWN ON THE RIGHT (STIRLING EXPERIMENT SHOWN ON THE LEFT)

Runs 8 through 17 (Test Nos. 4 through 12) and Run 21 had the full dish area, i.e. none of the 220 available mirrors were covered. Figure 2-1 shows this configuration.

Run 18 (Test 13) had 50 percent masking in an FACC-derived "checkerboard" pattern in which every other mirror was covered. Figure 3-4 is a photograph of this configuration.

The next two runs (19 and 20, Tests 14 and 15) had the 25 percent masking checkerboard pattern shown in Figure 3-5. This pattern was achieved by removing every other covered mirror in the previous 50 percent configuration. A photo of the TV screen showing the "spot" pattern on the back wall of the receiver for the 25 percent checkerboard pattern is presented in Figure 3-6. Each bright spot was from an individual mirror on or near the edge of the dish. Note that this spot pattern was symmetrical and covered most of the back wall. (The no-masking configuration filled in the dark areas shown in Figure 3-6 except for a small region ~4 inch diameter in the center.) The rain water drain in the center of the back wall of the receiver proved to be a valuable aid in determining if the beam was centered with respect to the receiver. Manual adjustment of the concentrator tracking was required to center the beam during periods of low insolation and mid-to-late afternoon operation.

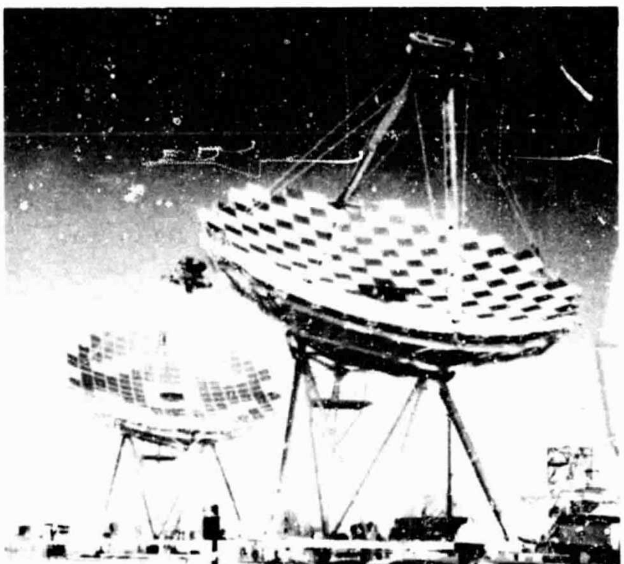

FIGURE 3-4. PHOTOGRAPH OF 50% "CHECKERBOARD" PATTERN. (TEST CONDUCTOR AND APPROVED CARS SHOWN IN FOREGROUND.)

FIGURE 3-5. PHOTOGRAPH OF 25% CHECKERBOARD MASKING PATTERN

FIGURE 3-6. PHOTOGRAPH OF TV MONITOR SHOWING 25% MASKING SPOTS ON BACK WALL OF RECEIVER. MODULE IS SEEN THROUGH WINDOW.

3.5.2 SOLAR INSOLATION

The solar insolation available during the test period covered the range of zero to one instance of slightly over 1000 W/m^2. A number of days were so cloudy, or the clear periods so infrequent, that tests were not possible. At least two weeks had only one or two days of good sunshine. It was determined that the lowest insolation for sustained PCA operation was approximately 300 W/m^2 for the full TBC area. At this level all SCSE subsystems would be operating at or slightly above the parasitic power level, i.e. little net power would be produced.

Insolation measurements were taken by a local Eppley pyrheliometer; first by a unit that was mounted on a tracker south of TBC No. 1, and then with an Eppley mounted directly to the TBC structure and aligned with the sun. Most tests were run with the dish-mounted Eppley which had the advantage of having the TBC act as an accurate tracker and by showing when the sun was acquired and detracked. Insolation data were also obtained from the JPL weather station. Weather station data were updated at one minute intervals (by JPL) and included two Kendall and one Eppley pyrheliometers, and a pyranometer. As documented in the Power and Energy Program write-up (Ref. 23), the local Eppley reading was modified to account for an average circumsolar effect in the calculation of the power available to the TBC.

3.5.3 TRANSIENT INPUT POWER

Input transients were obtained by closing the water-cooled sliding plate (door) for periods of 30 seconds to five minutes. Clouds were present on many occasions, but were not as convenient (or controllable) as closing the door. It was found that the engine would keep running for about 4.5 minutes after door closure at normal operating conditions, provided the control subsystem immediately commanded IDLE mode (~35,000 rpm turbine speed) to maximize the running time.

3.5.4 INVERTER INPUT (DC) VOLTAGE LEVEL

The dc voltage was varied from about 480 to 560V to determine the best operating point in terms of engine efficiency. It was found that the lower voltages (lower turbine speed) were best from this standpoint (see Paragraph 4.2.3), and most of the testing was in the range of 500 to 520 Vdc to the inverter.

3.6 TROUBLE/FAILURE REPORTS

Problems experienced at the PDTS were documented on a Trouble/Failure Report (TFR), FACC form ARD 7126. A copy of the form is shown in Report 007 (Ref. 2). The TFRs identified the part associated with the problem, provided a statement of the problem (cause and description) and identified the corrective action taken and required in the future (as required). Copies were sent to the appropriate JPL and FACC personnel.

SECTION 4

TEST RESULTS

This section presents a discussion of the important results from the tests at the JPL PDTS. The test run summary is presented in Section 1 of this report (Table 1-2) and should be referred to for general test information. Paragraph 4.1 presents a chronological summary of the major events that took place during the 16 tests; details of the individual tests and a plot of the time history of three selected parameters are presented in Appendix A. The remainder of this section is concerned with the performance of the components/subsystems (Paragraph 4.2) and the overall one-module system (Paragraph 4.3).

The results of the verification tests and the limited qualification testing of the two major elements of the electrical transport subsystem are given in Paragraph 4.2.4. These elements are the inverter and switchboard. The portion of the qualification tests performed at the PDTS could not be obtained earlier during testing at FACC or the subcontractor.

4.1 PDTS ACTIVITY AND RESULTS SUMMARY

Most of the month of January 1982 was spent in: (1) packing and shipping the SCSE equipment to the site (January 5-8), (2) equipment set-up (January 11-15) and (3) equipment checkout (January 18-February 5). The PCA was mated to the TBC on January 15 using the procedure documented in TP-006 (Reference 12).

The first engine start-up (Run 3, Test No. 1) was accomplished on February 8, however, a bad temperature sensor reading was noted for the key (control) thermocouple in the receiver and the test run was terminated after four minutes for replacement of the thermocouple. The next run was made on February 11 and lasted 20 minutes and was automatically terminated by the control subsystem when one channel was out of tolerance. A restart was attempted after it was found that the original fault cleared up and was not recurring, however the throttle valve could not be opened. The PCA was removed from the dish to diagnose the problem. Disassembly of the PCA and the control valve elements revealed the problem to be in the MOOG servo valve.* A new MOOG valve was substituted and the PCA reassembled.

The PCA was reinstalled on the concentrator on February 19 and runs of 5.3, 1.4, 2.7, and 4.1 hours (Runs 7 through 11) were accomplished on February 23 through 26. Runs 12 through 21 (Tests 7 through 16) were completed in March. The engine test time was 13.9 hours in February and 19.7 in March for a total of 33.6. The complete data recording was made for each run at one second intervals. In addition, accelerometer data were recorded for two locations on the turbine/alternator/pump (TAP) housing. These data were displayed on the screen of a spectrum analyzer and recorded on a JPL-provided tape recorder for analysis and evaluation (see Paragraph 4.2.3).

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*Analysis of this valve indicated that contamination or a small particle had prevented the operation of a key element of the servo.

The inverter began to show evidence of improper operation in Run 17 and this was traced to the grounding of a choke in the SCR circuit. No problems were experienced after this was corrected until attempts were made to run the inverter into the local grid using the Nova power supply as the input. The Nova Chief Engineer came to the PDTS on March 23 to correct the problem and the first grid hookup using the PCA was made on the last run which occurred on March 26 (Run 21). The operation was smooth until clouds reduced the power output of the PCA to an "idle" condition. When this occurred the input current to the inverter approached zero and the unit began to have control and/or SCR problems which could not be corrected at the site. The circuit boards which were malfunctioning were partially repaired at the Nova plant and later returned to the site for installation and checkout.

The data were analyzed to obtain the efficiency of the receiver, PCS, and the inverter, and the results are described in Paragraph 4.2. The performance and efficiencies were calculated at one second intervals on a real-time basis using the Power and Energy Program documented in TR SCSE-044 (Reference 23).

Experiments were run in which both the Nova dc power supply* and the PCA operated simultaneously into the inverter. In two cases the inverter was putting power into the load bank (Runs 18 and 20); in Run 21 the power was put into the local PDTS grid via the JPL interface box located at the south end of Trailer No. 2. No problems were experienced during these experiments, and it was concluded that the inverter will provide the proper control for multiple modules, provided, of course, the maximum power capacity of the existing unit ($\sim$40 kVA) is not exceeded.

The Nova dc power supply proved to be invaluable in checking out the operation of the inverter as well as performing the experiments outlined above. The combined power output of the power supply/PCA setup was as high as 26.8 kW, which allowed the demonstration of the principle of multiple module operation and the measurement of the efficiency of the inverter at higher power than was possible with the PCA alone.

The system demonstrated it was completely controllable, stable and well behaved even for transient power inputs caused by door closures of 30 seconds to five minutes. Operation was smooth even when the hardware was subjected to multiple starts, restarts, and transients. Performance generally was as predicted from the earlier tests at the FACC ATC facility. Details are continued in the following paragraphs, and an event summary and sample plot for each run is given in Appendix A.

4.2 COMPONENT/SUBSYSTEM PERFORMANCE

Real-time information on component and subsystem performance was available in raw form from the CRT by selecting the Power and Energy Display (display number 1). A print or plot of this information could be obtained immediately after a run by selecting the proper parameters for tape play-back. (Real-time print-out of data was also possible, but this option was rarely exercised.)

*Used at Nova for the initial testing of the inverter.

A complete description of the Power and Energy Program (Program OPWEG) is documented in Reference 23; key assumptions and parameters for the various subsystem calculators are outlined in the following paragraphs. A sample print-out from Program OPWEG is presented in Appendix B, and sample plots of selected performance parameters are shown in Paragraphs 4.2.2 through 4.2.5.

As each test run was completed at the PDTS, key data print-out and plots were made for the entire test period. Special events were examined by making plots over a time scale commensurate as to the event, and/or print-outs for intervals as short as one second. Copies of the print-outs and plots were made by JPL within a day or two after a run and distributed to JPL and FACC personnel.

4.2.1 TEST BED CONCENTRATOR (TBC)

The power delivered by the TBC to the receiver aperture was an important parameter in the calculations, and was derived from the output of the local Eppley pyrheliometer and the predicted performance of the TBC. The power to the aperture (PT3) for no masking was calculated* by the following:

$$PT3 = (PM1)(K_c)(A_c)(\rho)(K_d)(K_b)/1000, \text{ kW} \tag{1}$$

where:

PM1 = Eppley reading (W/m^2), measurement No. 016

K_c = Avg. circumsolar factor = 0.965

A_c = Effective area of TBC = 87.6m^2 for Run 16 through Run 21 (= 92.41m^2 prior to Run 16)**

ρ = Avg. reflectivity = 0.950

K_d = Avg. dust factor = 0.975

K_b = Blockage ratio = 0.9706***

The rationale for selecting these values is given in Ref. 23. The "efficiency" of the TBC (collector efficiency) is obtained by combining the last three factors, which yields η_{TBC} = 0.899. It is not appropriate to include the circumsolar effect as part of the concentrator efficiency since it represents power which cannot be focused or utilized.

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*All calculations in Program OPWEG were made real-time, once per second.

**A_c = 87.6m^2 was derived from JPL calorimeter measurements of 75.7 kW thermal output from the TBC for a 1000 W/m^2 day. Since the maximum output of the concentrator was only 75.7 kW$_t$, the receiver and engine could not be operated close to the design condition of 95 kW$_t$ input at the receiver aperture.

***K_b was updated after the runs were completed to yield a value of 0.967.

The values calculated for PT3 (Eq. 1) were used as the input power to the receiver since the intercept factor (γ) was essentially unity. This was verified by JPL by positioning the mirrors to meet a FACC requirement of having $\geq$ 96% of the beam's energy inside a 10-inch diameter circle. The aperture diameter was 15 inches.

4.2.2 RECEIVER

Program OPWEG Calculations. Program OPWEG determined the power out of the receiver by two different techniques, called 'measured" and "calculated." The measured power out (PM4) was obtained from the use of a B-N mass flow correlation and the calculated enthalpy rise of the toluene through the receiver. The theoretical value of power out (PT4) was based on the calculated heat loss for the receiver due to reradiation, conduction, convection, and reflection effects. The ratio of the input and output values was used to calculate the measured and theoretical receiver efficiency (ET4 and EM4, respectively). The receiver data shown below are the actual realtime output from the program, stored on tape until plotted(or printed) out. Therefore, it should be recognized that the plots are based on raw data. Print-outs of receiver power and efficiency for a typical run are contained in Appendix B.

Sample Results. Due to the quantity of the data, selected representative cases are shown to illustrate the performance of the receiver and other components in the system. Figure 4-1 presents the measured receiver efficiency, solar insolation and wind speed for a typical afternoon test run (Run 16). The insolation level averaged about 900 W/m^2 during the 90-minute operating period, and the wind speed was about 5 mph. The average receiver efficiency based on measured power is seen to be approximately 95 to 96 percent. This compares almost exactly (within experimental limits) to the predicted receiver efficiency of 96.4 percent for a 900 W/m^2 day. Since receiver efficiency is a function of input power, the value for Run 16 was slightly less than the predicted 97 percent efficiency at the design power level of 95 kW_e. The fluctuations in the plot of receiver efficiency in Figure 4-1 are primarily a result of small changes in valve position causing small changes in the mass flow correlation, which in turn causes a considerably larger relative change in efficiency.

Figures 4-2 and 4-3 present receiver temperatures for various operating conditions during a 6.7-hour test (Run 13)*. As shown in Figure 4-2, the insolation level was high throughout the day with the exception of a short duration, high cloud observed during the morning start-up. The receiver fluid (toluene) outlet temperature reached the steady-state operating level of 750°F (400°C) 20 minutes after start-up. After approximately 45 minutes of steady-state operation the water cooled door was closed to simulate a 4.5 minute cloud passage. As shown in Figure 4-2, the valve position was automatically changed to about 23 percent open in order to try to maintain the toluene outlet temperature at 750°F. This resulted in the turbine operating in the "IDLE" mode at 35,000 rpm throughout this period. The toluene outlet temperature

*A print-out of all the data for this run between the time of 12:00:00 and 12:00:54 is given in Appendix B.

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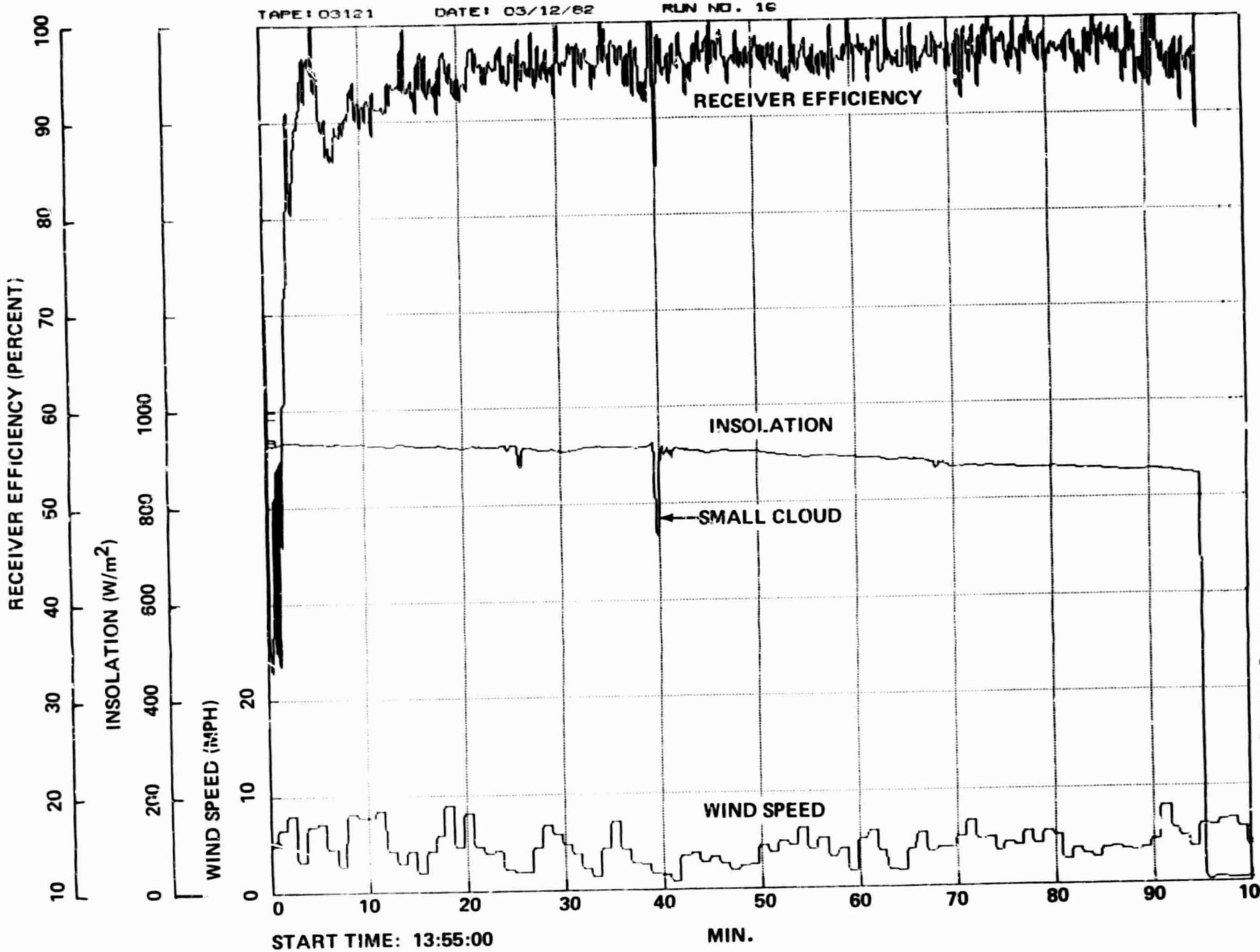

FIGURE 4-1. TYPICAL RECEIVER EFFICIENCY PLOT (RUN 16, TEST NC. 11)

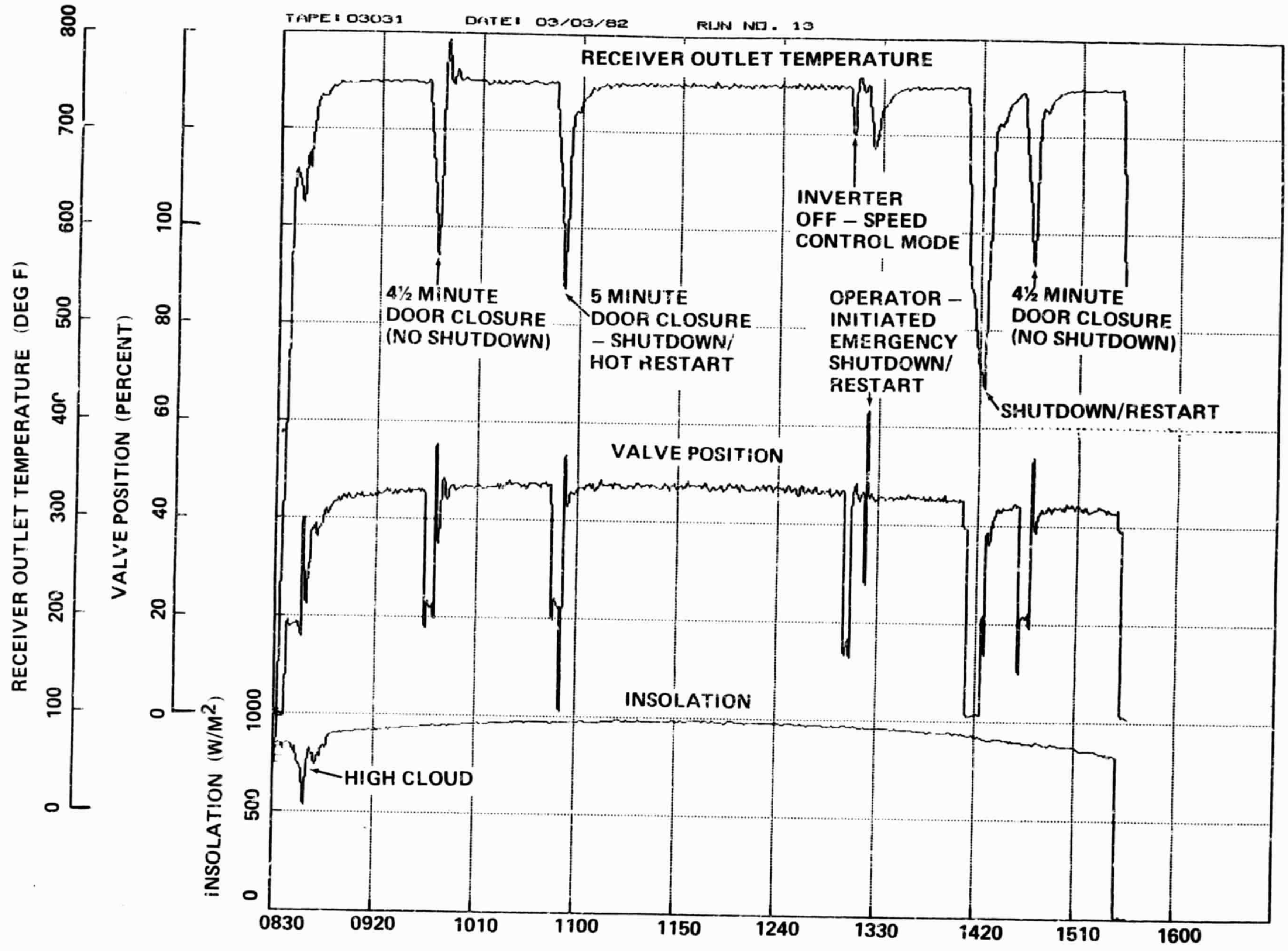

FIGURE 4-2. RECEIVER FLUID OUTLET TEMPERATURE VERSUS VALVE POSITION (RUN 13, TEST NO. 8)

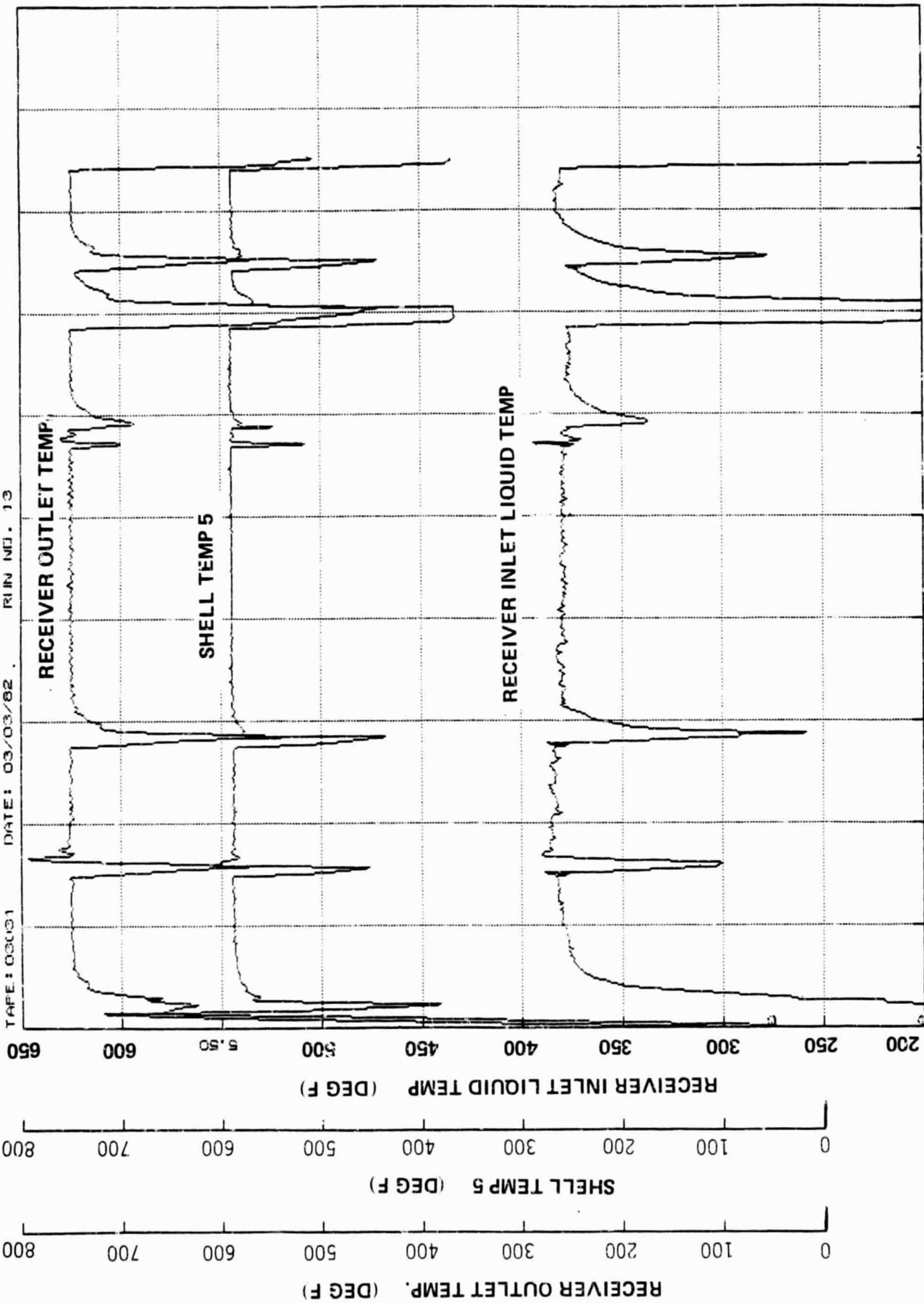

FIGURE 4-3. RECEIVER TEMPERATURES FOR RUN 13 (TEST NO. 8)

(and receiver shell temperatures) decreased throughout the simulated cloud passage (see Figure 4-3). At the end of the 4.5-minute period, the door was reopened, permitting the receiver to heat up and reach the normal operating conditions again. For this particular test of door closure the toluene outlet temperature overshot the desired temperature by approximately 40°F before stabilizing at 750°F. This was eliminated in the subsequent 5-minute door closure test by modifying the control logic while the test run continued. The effect of this change is clearly demonstrated by comparing the receiver outlet temperature for the 5-minute door closure at 10:50 with the earlier 4.5-minute case (see Figure 4-2). As shown in this second case, the toluene temperature quickly increased to approximately 720°F and then rose slowly to the desired 750°F outlet temperature.

The receiver operated at a subcritical toluene pressure range of approximately 480 to 550 psia for steady state conditions throughout the test runs, including Run No. 13 illustrated in Figures 4-2 and 4-3.* Transient conditions changed the pressure level; for example, it dropped as low as 300 psi during door closures or cloud passages of several minutes. Figure 4-4 presents a pressure history for a case with a series of clouds (Run No. 17) whose duration and intensity are indicated by the plot of solar insolation. The pressure response around the time of 8:40 was due to the "burping" or relief of the pressure before turbine start-up. The receiver outlet temperature plotted at the top of Figure 4-4 shows only minor perturbations around the control value of 750°F due to cloud passage. As a result of these tests, it was concluded that the fluid outlet temperature control was validated and was not subject to any undesirable overshoot during the most severe transients.

Figure 4-5 presents receiver wall temperature data for two steady-state cases (Runs 13 an 17) compared to the original design prediction documented in Reference 6. The comparison is quite good considering: (1) the assumed fluid inlet temperature for the prediction was 20°F higher than for the tests, (2) the predictions were based on supercritical flow (600 psi fluid pressure) whereas all the tests were conducted at subcritical conditions (480 to 550 psi fluid pressure), and (3) uncertainty in the flux distribution from the TBC. Note the data for the two runs are very close even though the input power to the receiver for Run 13 was 20 percent higher than for Run 17. All the data were obtained from thermocouples except for two RTDs (resistance temperature detectors) at the same location as thermocouple number 3. No problems were experienced with the receiver temperature sensors except for the first test (Run No. 3) in which the receiver control thermocouple (Temperature No. 5, RCSTP5) read abnormally low. This was corrected by using the spare at location 5 for subsequent runs. (All temperature sensors were redundant.)

Summary. The receiver performed extremely well during all solar tests at the JPL PDTS. As in the case of the receiver development and qualification tests (References 6 through 9), the unit demonstrated excellent performance during all of the various test conditions. Boiling and/or flow instabilities and local "hot spots" were not observed during any of these or previous tests, including the subcritical, two-phase flow regime in which the unit operated most of the time, but which was not the original design condition. No design deficiencies were found, and it was concluded that the basic receiver design

*Subcritical operation was due to the speed (i.e. voltage) selected for these test runs.

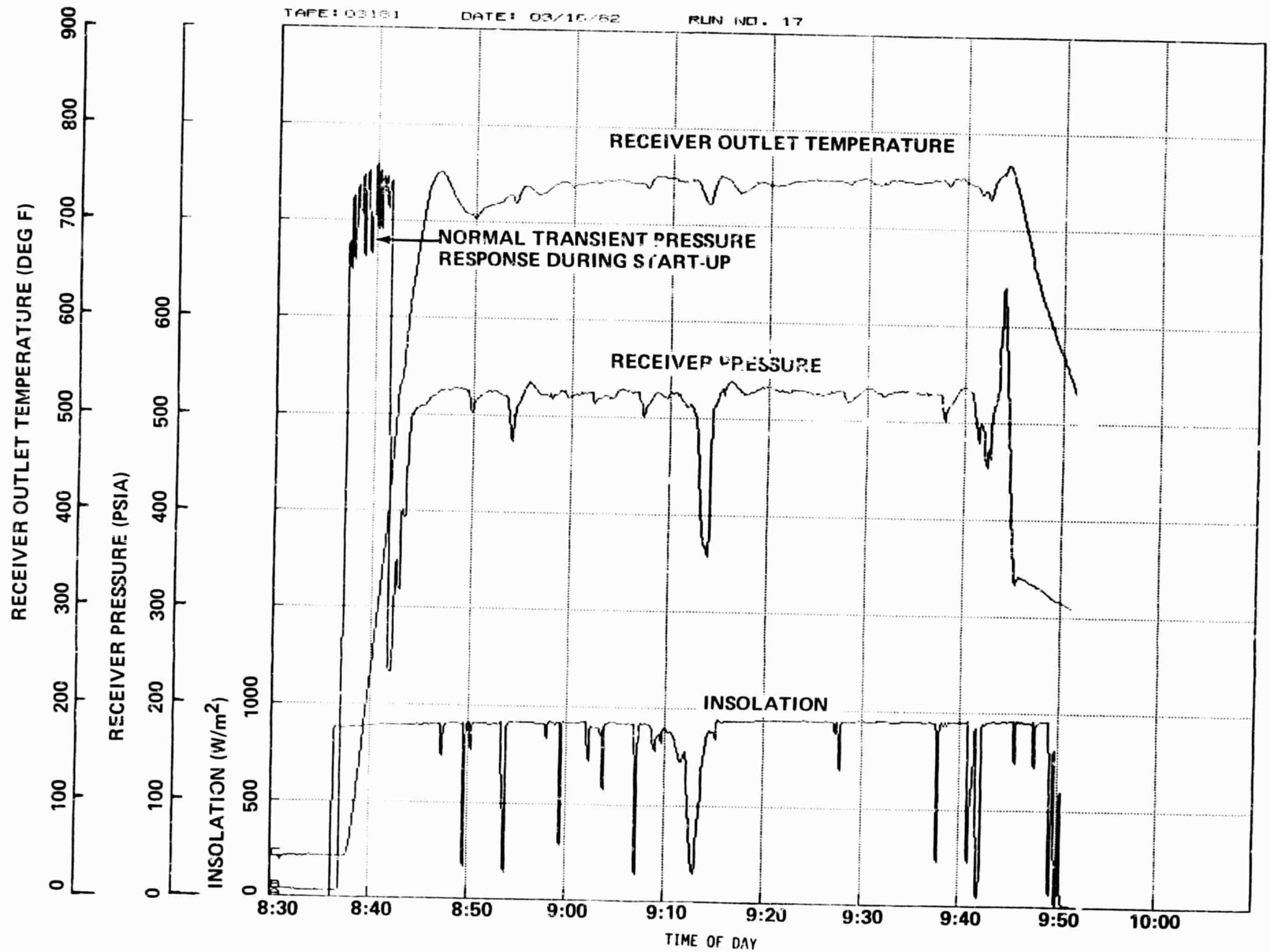

FIGURE 4-4. EFFECT OF CLOUD PASSAGES ON RECEIVER PRESSURE AND FLUID OUTLET TEMPERATURE (RUN 17, TEST NO. 12)

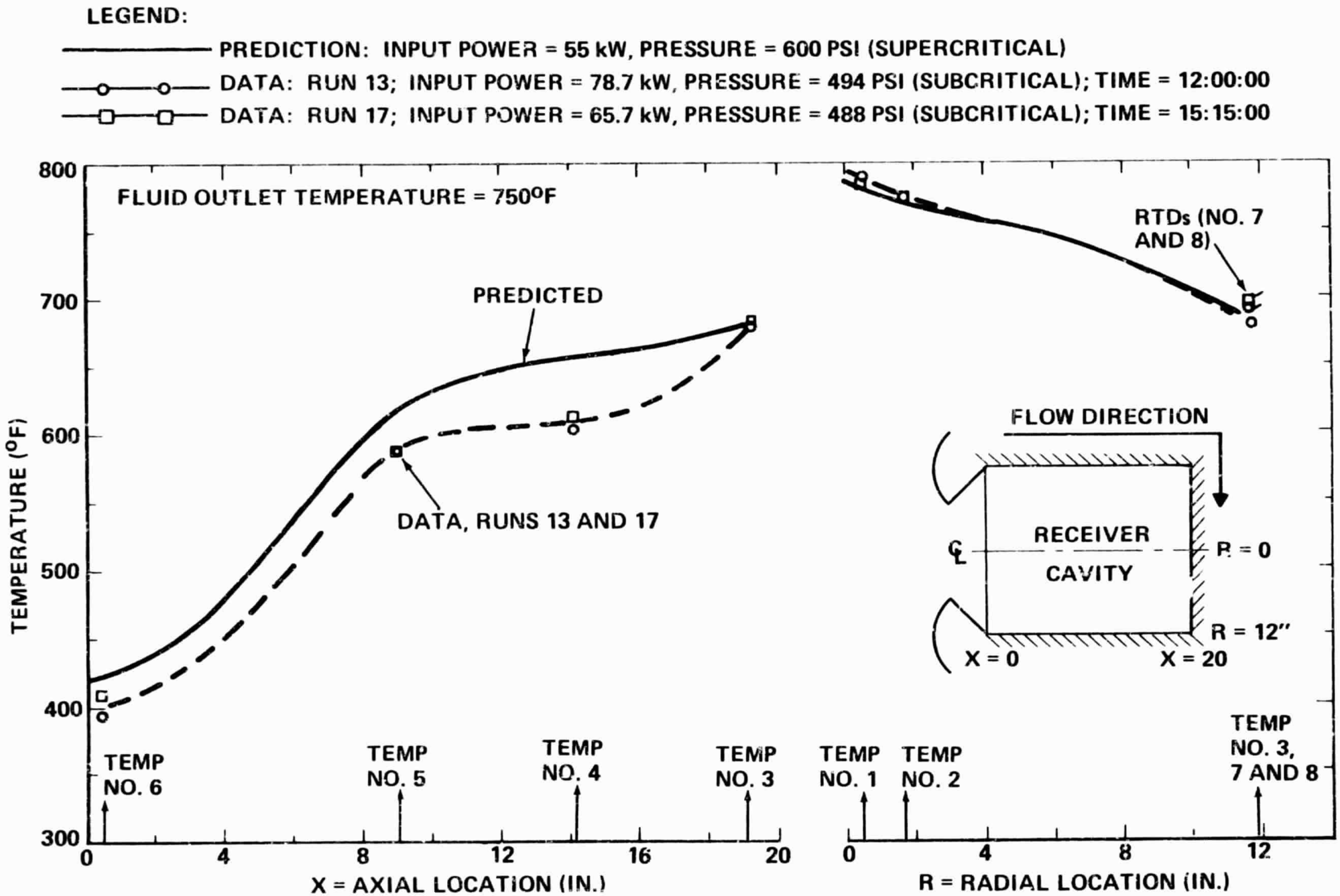

FIGURE 4-5. COMPARISON OF PREDICTED AND MEASURED RECEIVER WALL TEMPERATURES (RUNS 13 AND 17)

meets or exceeds all of the performance requirements for the SCSE application and is a very forgiving design. This is primarily due to the large copper core which acts as "buffer" storage for thermal energy eliminates any potential hot spots by lateral and axial conduction.

4.2.3 POWER CONVERSION SUBSYSTEM (PCS)

Program OPWEG Calculations. Power delivered to the PCS was, by definition, identical to the output from the receiver. Measured gross power out of the PCS (PM5) was obtained from the electrical (dc) sensors in the switchboard, corrected for the cable loss between the PCS and the sensors. Theoretical power out (PT5) was calculated based on the PCS efficiency correlations published in Reference 23. These represent net power since parasitic losses were included in the correlations.

Parasitic power to operate the pumps and fan was not used in the OPWEG calculations for measured power out during this test series. However, accurate measurements of this parasitic loss were made at the PDTS as discussed below, and will be incorporated in the measured PCS efficiency calculations (EM5) for the next test series.

Performance. Figure 4-6 presents the time history of PCS input (receiver output) and output power and efficiency for the same run used for some of the receiver plots (see Figures 4-2 and 4-3). Figure 4-6 was obtained from the real-time output of Program OPWEG which in turn used the direct output of the sensors. The sharp dips in the curves were caused by door closures and operator-initiated shutdowns identified in Figure 4-2. The results show the PCS efficiency was about 22.5 percent at PCS input power of $\sim$70 kW_t. Note, however, the plots of power output and efficiency can be misleading because of the requirement to achieve steady state conditions. At least 30 minutes was required after each of the transients in Run 13 before steady conditions were again reached. Since the primary purpose of Run 13 was to evaluate various control parameters for different lengths of simulated cloud passages (door closures), the periods of steady state operation were only a fraction of the 6.7 hour run.

A series of points were taken from the data for the run plotted in Figure 4-6 and from other runs at times which represented the performance at steady-state or near-steady-state conditions. These were averaged over a representative time interval and are summarized in Table 4-1. The gross power was corrected to a net value in column 5 by subtracting the measured parasitic power for the fan and pump (688W for high fan speed and 373W for low speed). The results from Table 4-1 are summarized by the plot in Figure 4-7. The dashed line shown in the figure does not represent a curve fit of the data points, but rather it was taken directly from the Barber-Nichols PCS Qualification Test Report of November 1981 (this curve is also documented in Reference 23, including the variation of efficiency with ambient temperature). A comparison of the data points with the curve in Figure 4-7 indicates good agreement at medium to high input power, especially since the runs were made at an ambient temperature that averaged 55 to 60°F. This ambient temperature results in about a one point increase in efficiency compared to that for the

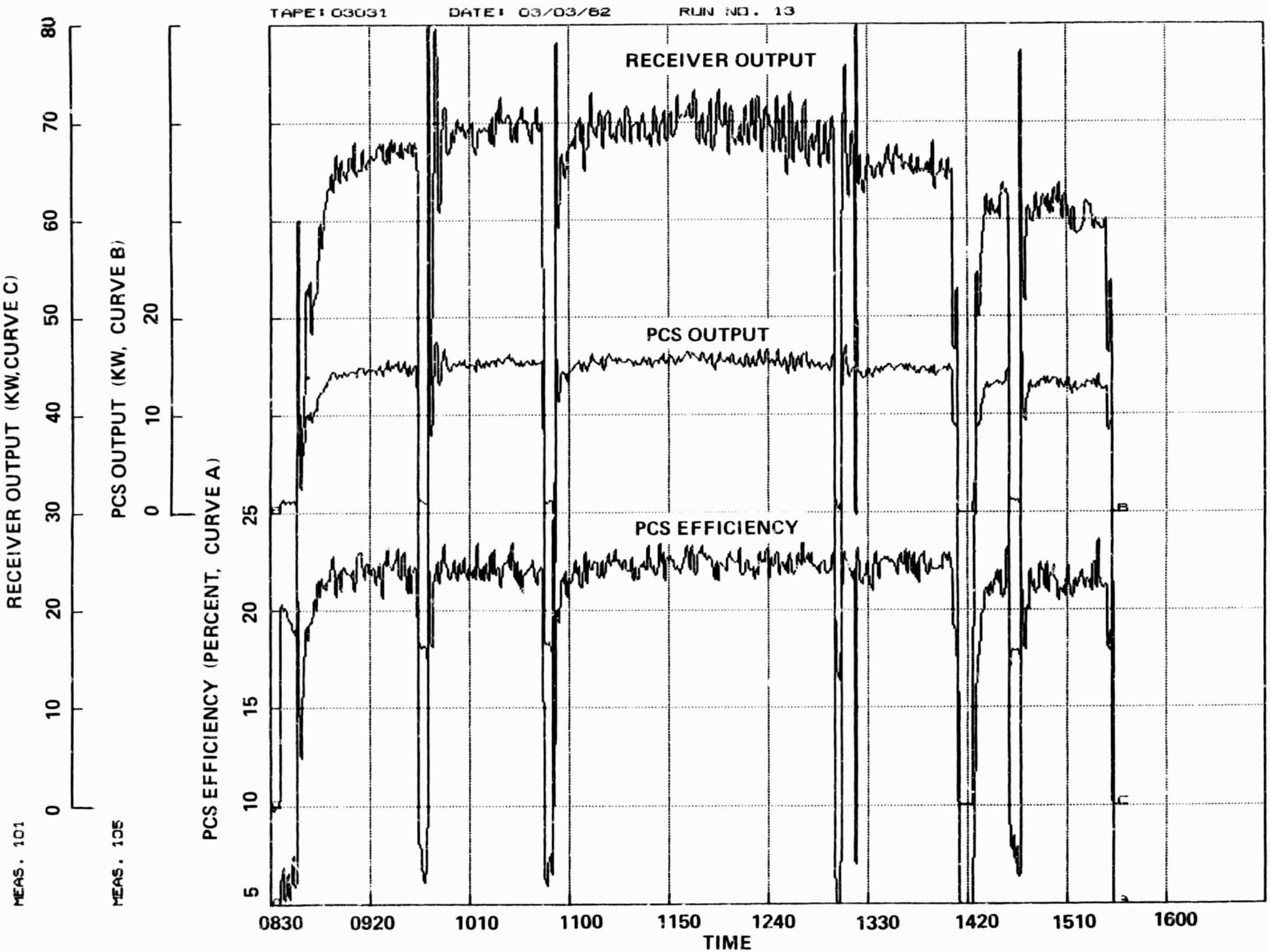

FIGURE 4-6. PCS PERFORMANCE HISTORY FOR RUN 13 (TEST NO. 8)

TABLE 4-1. PCS TEST DATA AT PDTS

Run No. (Date)	Time	Power to PCS, PM4 (kW_t)	Gross Power Out, PM5 (kW_e)	Net PCS Power Out* (kW_e)	Net PCS Eff.	Fan Spd.	dc Volts	Mask. (%)	Amb. Temp (^oF)
8 (2-25)	09:46	58.0	12.7	12.0	20.7	HI	500	0	52
9 (2-25)	14:00	67.0	14.0	13.6	20.3	LO	500	0	66
11 (2-26)	12:10	72.0	16.0	15.3	21.3	HI	500	0	62
	13:32	55.5	11.2	10.5	18.9	HI	500	0	68
13 (3-03)	10:50	69.0	15.3	14.6	21.2	HI	500	0	54
	12:00	70.4	16.2	15.5	22.0	HI	500	0	55
	13:55	65.0	15.0	14.3	22.0	HI	500	0	54
	14:50	61.5	13.2	12.5	20.3	HI	500	0	53
17 (3-18)	09:36	66.4	14.5	13.8	20.8	HI	500	0	45
18 (3-19)	12:30	36.5	5.0	4.6	12.7	LO	500	50	51
	12:50	36.5	5.0	4.3	11.8	HI	500	50	52
	13:30	35.0	4.0	3.3	9.5	HI	550	50	52
19 (3-19)	15:28	47.5	8.5	7.8	16.5	HI	500	25	53
20 (3-22)	12:18	52.7	10.8	10.1	19.2	HI	500	25	60
	13:00	34.5	4.7	4.3	12.5	LO	500	25	60
	13:05	42.0	7.0	6.6	15.8	LO	500	25	60
	13:15	51.0	9.2	8.8	17.3	LO	500	25	61
	13:56	16.5	1.3	0.6	3.7	HI	500	25	60
	14:40	49.5	9.0	8.3	16.8	HI	550	25	61

*Net Power = PM5 minus parasitics

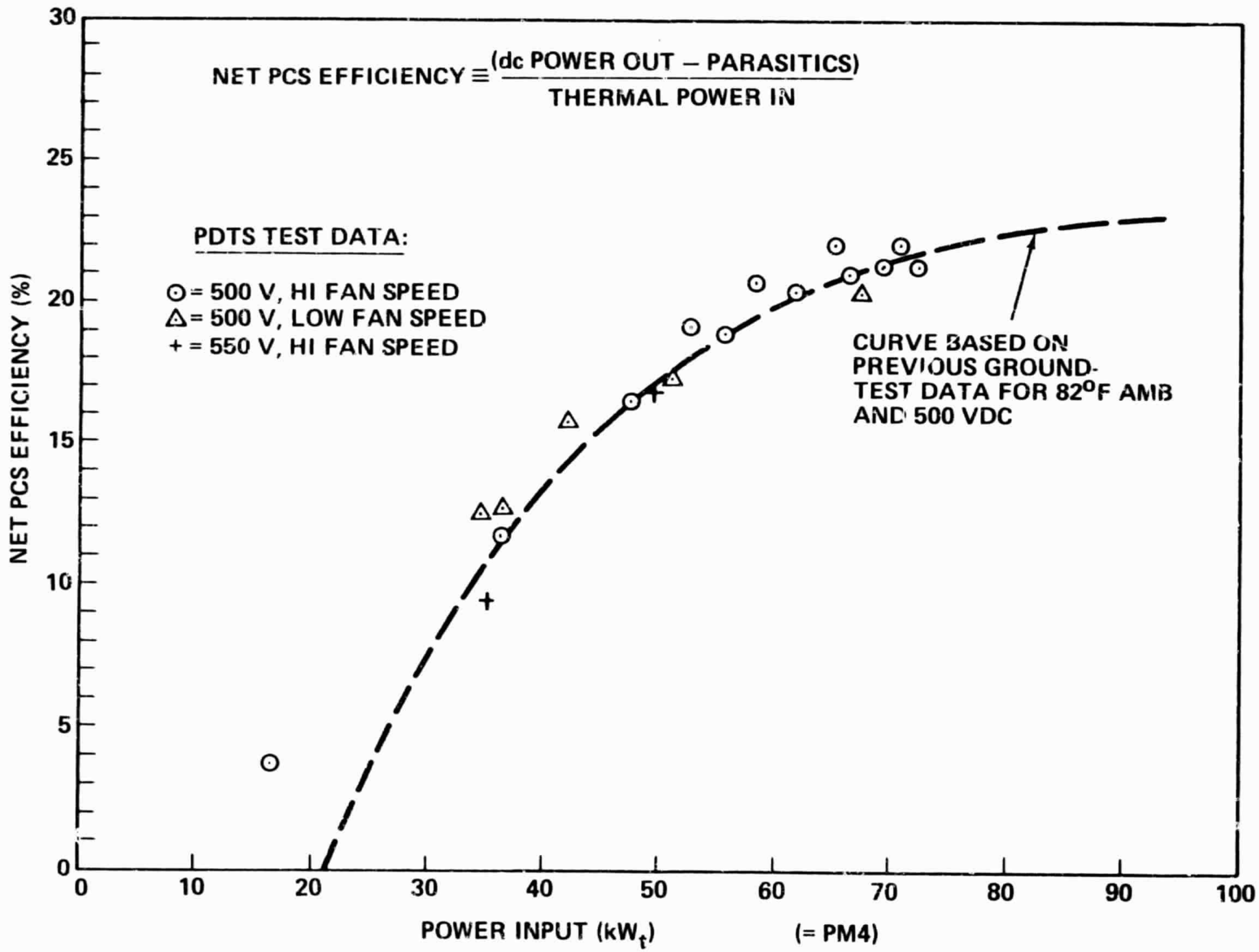

FIGURE 4-7. MEASURED ORC ENGINE EFFICIENCY (NET AFTER PARASITIC POWER SUBTRACTED)

82°F line in Figure 4-7. Data for lower power show a tendency for higher than predicted efficiencies at low fan speeds.

PCS parasitic power consisted of the electrical power required to run the PCS fan, boost pump, valve drivers, data transmitters, etc. This was supplied at the PDTS by the local grid via the UPS. Actual power values were measured at the switchboard with a wattmeter for the PCS in its normal operating modes. The total parasitic power requirements were:

- At high fan speed*, 688W
- At low fan speed*, 373W

In high wind conditions the fan power may be reduced from these no-wind values due to the added cooling resulting from the flow over the fan and condenser.

It was determined, as expected, that high fan speed yielded better performance at high input power levels, and low fan was better at lower power level. The cross-over point was about 40 to 50 kW_e, depending on ambient temperature and wind velocity. Further testing will be necessary to establish the best control algorithm for switching to low fan speed and minimizing the parasitic losses for the PCS. Preliminary results obtained in these tests indicated that net positive power should be produced down to input power levels around 10 kW_e, which is a significant improvement over the previous 22 kW_e estimate plotted in Figure 4-7.

One significant item that directly affected the PCS efficiency was the condenser pressure. An increased condenser exit pressure of only 0.7 psi (from 1.1 to 1.8 psia) during Run 16 reduced the PCS efficiency by about two points (~19% as compared to ~21% normally). This increase in pressure - whether due to leaks, build-up of noncondensable gases or increased condenser temperature - is directly reflected in a reduced expansion ratio across the turbine and thus a reduction in the PCS efficiency. Good hermetic seals and the removal of noncondensable gases will be important in future power plants of this type. It is planned to obtain additional data on the effect of condenser pressure in future tests.

A limited number of tests were run with the inverter set to control the dc input voltage to levels higher than the nominal 500 to 510 Vdc. This resulted in a higher turbine speed since speed is proportional to voltage (see Paragraph 4.2.5 for a further discussion). These tests verified earlier data that higher voltage (speed) results in lower PCS efficiency, and is caused by the unique design of this prototype pump/nozzle/turbine. (Note the two 550V points plotted on Figure 4-7.) This is because at any given power level, lower voltage corresponds directly with lower turbine/PMA speed. But as speed drops, the pump work decreases dramatically, which turns out to be a very important factor. The combined effects of higher than predicted turbine backpressure, nozzle underexpansion and an oversized feedpump designed for critical presures, resulted in better PCS efficiency at lower speed/voltage ranges.

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*Previous values used by Barber-Nichols were 1.16 kW and 0.66 kW, respectively.

Performance improvements are planned to be made by optimizing the pump and nozzle designs. Although ~500 Vdc proved to be best from the standpoint of PCS efficiency, it is not optimum from the standpoint of the inverter efficiency, cable losses, and other factors. Therefore, attempts will be made in the next test series to raise the voltage (while maintaining the same speed) by adding capacitors to the circuit. Ultimately, this and other design modifications will be utilized to reach a level close to the 600V used in the original specifications, while maximizing PCS efficiency.

Toluene Analysis. A number of toluene samples were taken from the unit during repair and maintenance operations and analyzed by JPL. The first samples were taken after Run 5, and were discolored with 0.04 to 0.05 percent of aliphatic hydrocarbons and phthalate esters. A cold trap was used in the subsequent pump down operations to minimize the possibility of having vacuum pump oil reach the system. A sample taken after the last run was clear and had only 0.004 percent of residue of phthalate and polyglycol, indicating that the cold trap was effective and/or the original residue had been largely flushed out. Further data are required to evaluate the effect that residue and toluene breakdown products have on the long-term performance of the system.

Accelerometer Data. Radial and axial accelerometers were mounted on the pump-end of the TAP. Charge amplifiers were used to determine the overall accelerations, and a spectrum analyzer provided acceleration data at various frequencies. An FM tape recorder was used by JPL personnel to record the data for the first 1.5 hours of testing, and at selected periods thereafter. Typical results are presented in Reference 25. The overall measurements for the axial and radial accelerometers were 0.7 to 1.0 g's and 25 to 29 g's, respectively. The spectrum analyzer showed very narrow, well defined spikes which were always exact multiples of the synchronous speed. The readings were unchanged over the test period.

Summary. The overall performance of the PCS during the 33.5 hours of testing was close to the predicted values. Measured parasitic power was only about half that predicted. The TAP ran smoothly during all the tests and the noise level was low, being limited to a normal high-pitched turbine whine. The acceleration levels were also relatively low and constant throughout the tests. Inspection of the TAP after the conclusion of these tests showed that further bearing work is needed. This was initiated in May, 1982 and improved designs will be used in the next test series.

4.2.4 ELECTRICAL TRANSPORT SUBSYSTEM (ETS)

The ETS consisted of the switchboard, inverter and ancillary equipment such as power cabling, junction boxes, etc. Of primary concern was the performance of the inverter since it not only converted dc to grid-compatible power, but also performed the key control function of maintaining the proper turbine/alternator load via voltage control.

The tests at the PDTS were the first in which the switchboard had been used. The earlier ATC tests reported in Reference 10 had the inverter in place, but the power was dissipated in a load bank. Therefore, the tests

reported here are considered as partial qualification for the inverter and switchboard. All general requirements were achieved during these tests; however, additional measurements are needed in future tests to verify specific requirements for the grid-connected mode.

Inverter Requirements. The primary requirements for the inverter were to convert dc input power to grid-compatible ac power and to maintain input voltage within two percent of the desired value. Table 4-2 lists the requirements and the resulting test observations. As noted in the table the major requirements were achieved except for switching from the grid to the load bank at low power output. The solution to this problem has been identified and will be corrected before the next test phase.

Program OPWEG Calculations. Program OPWEG was used to calculate the output power from the inverter for two options: load bank connected, or grid connected. Measured output power (PM6) was derived from the appropriate voltage, current, and power factor sensors in the switchboard. The theoretical output power (PT6) was calculated from the correlation of inverter efficiency versus input power (see Figure A-1 of Reference 23). Both the measured and theoretical inverter efficiencies (EM6 and ET6, respectively) were completed and printed out as part of the program outputs, as was the input and output power.

Sample Results for Inverter. The unique feature of the SCSE inverter is the use of an input voltage sensing circuit to vary the output duty cycle of the unit and thereby vary the effective input impedance in such a way that the input voltage is held nearly constant. By this technique the alternator is presented with a constant-voltage load and the turbine speed is controlled in a manner determined by the effective internal impedance of the alternator.

The operation of this control scheme is shown in Figure 4-8, which is a data plot from Run 17 (Test Number 12) which had a series of cloud passages (an insolation plot is shown in Figure 4-4). For this test the inverter voltage was set at about 510 Vdc and the inverter maintained this value within narrow limits over a wide range of generated power. When the input power dropped below a value of about 1.5 to 2 kW_e due to cloud passages at 08:53 and 09:13, the turbine speed dropped to a value such that the no-load rectified alternator output voltage was below the inverter control level. At this point the inverter went to its minimum duty cycle and could no longer control the voltage although the unit was still on the line and was drawing about 1.5 kW of parasitic power. The turbine speed was kept at the minimum speed limit of 35,000 rpm during this period (IDLE mode) by the throttle valve control law until the receiver shell temperature exceeded a preset limit and was within the linear range of the control law. When the turbine speed rose high enough so that the inverter voltage reached 510 Vdc, normal control was again achieved.

The turbine speed during normal operation was held within a range of about 47 to 51 krpm. This speed is plotted as a function of output power level in Figure 4-9. Changing the inverter control voltage level shifts this straight line to the left or right while maintaining the same slope. (The slope of the line is a function of the effective internal impedance of the alternator.)

TABLE 4-2. INVERTER REQUIREMENTS

Requirements	Test Results/Achievements	Comments
MAJOR:		
1. Produce grid-compatible ac power and ac power and ac power to load bank	• Load bank operation ok • Grid operation (Run 21) ok until idle condition or reverse current reached	• Control circuit to be modified to switch to load bank when reverse current sensed
2. Maintain input voltage within 2% (load control for turbine/alternator)	• Requirement met, voltage normally held within ± 5V (± 1%) for steady state operation	• Width of voltage band adjustable in inverter
3. Operate with input voltages between 500 and 630V	• Requirement met, some operation as low as ~475V and as high as 601V (high voltage run at ATC)	• Voltage setting adjustable. Tap on output transformer now set on lower range
4. Operate over a power range from 0 to 30 kVA	• Requirement met for all levels up to maximum available (26.8 kW)	• Unit should be operational to 40 kVA according to Nova
OTHER REQUIREMENTS:		
5. Input voltage ripple less than 5%; input current ripple less than 1%	• Believed to be acceptable, but a function of the rectifier, not the inverter	• Future measurements planned
6. Input and power source impedance (Para. 3.6.1.5 of Ref. 15)	• Acceptable; input impedance = 15.7 ± 0.2 ohms	• Future measurements planned
7. Output power factor of 0.95 ± 0.05	• Believed to be acceptable, but low voltage setting affects P.F.	• Future measurements planned
8. Output voltage: 480 $\pm$ 48V to grid	• Acceptable in Run 21; voltage to load bank not a requirement	• Future measurements planned

TABLE 4-2. INVERTER REQUIREMENTS (Continued)

Requirements	Test Results/Achievements	Comments
9. Output distortion and regulation (Para. 3.2.6.5, 3.2.6.6 of Ref. 15)	• Acceptable in grid test (Run 21)	• Future measurements planned
10. Efficiency: greater than 80% at power levels between 10-20 kVA	• Acceptable, test data shown in Figure 4-11	• Low input voltage (~500V) increases losses compared to design voltage of 600V
11. Protective circuitry, test circuits, controls, and switch contacts (Para. 3.6.4-3.6.6 of Ref. 15)	• Generally acceptable for normal operation; circuit modifications identified for grid-connected mode	• Reliability of circuits/components needs improvements

Typical dynamics during a turbine start for the same run (Run 17) are shown in Figure 4-10. Note that the time scale has been expanded to show only the first 10 minutes of the run. The initial spike on the dc voltage occurred before the relay on the inverter dc input "pulled in" and turned the inverter on. The inverter then remained on throughout the run and held the voltage at 510 Vdc except for short periods during the initial start-up when the turbine speed dropped below about 45 krpm.

Inverter Efficiency. Efficiency data were taken from four representative runs and plotted in Figure 4-11. Also shown on the figure is the original (pre-test) prediction of efficiency based on an input of 600 Vdc. The data are considerably higher than predicted at low to intermediate power levels, but slightly lower at input power levels above 17 kW. The inverter efficiency could be increased by having an input voltage closer to the design value of 600 Vdc, rather than the current PCS-dictated value of about 500 Vdc (see discussion in Paragraph 4.2.3). This would reduce the I^2R losses in the inverter and also improve the power factor. It is planned to test the inverter at the design voltage after the PCS modifications are implemented.

Note that the present inverter is actually a subscale version of what would be used in a future plant. It is expected that two or three inverters of about 10 times larger size would be used for a plant in the range of 0.5 to 1 MW_e. In this size the inverter efficiency is predicted to be 95 percent or higher at full load conditions.

Switchboard. The switchboard was first installed and checked out at the PDTS. The unit met the requirements in Reference 19 after some wiring errors were corrected by FACC personnel.

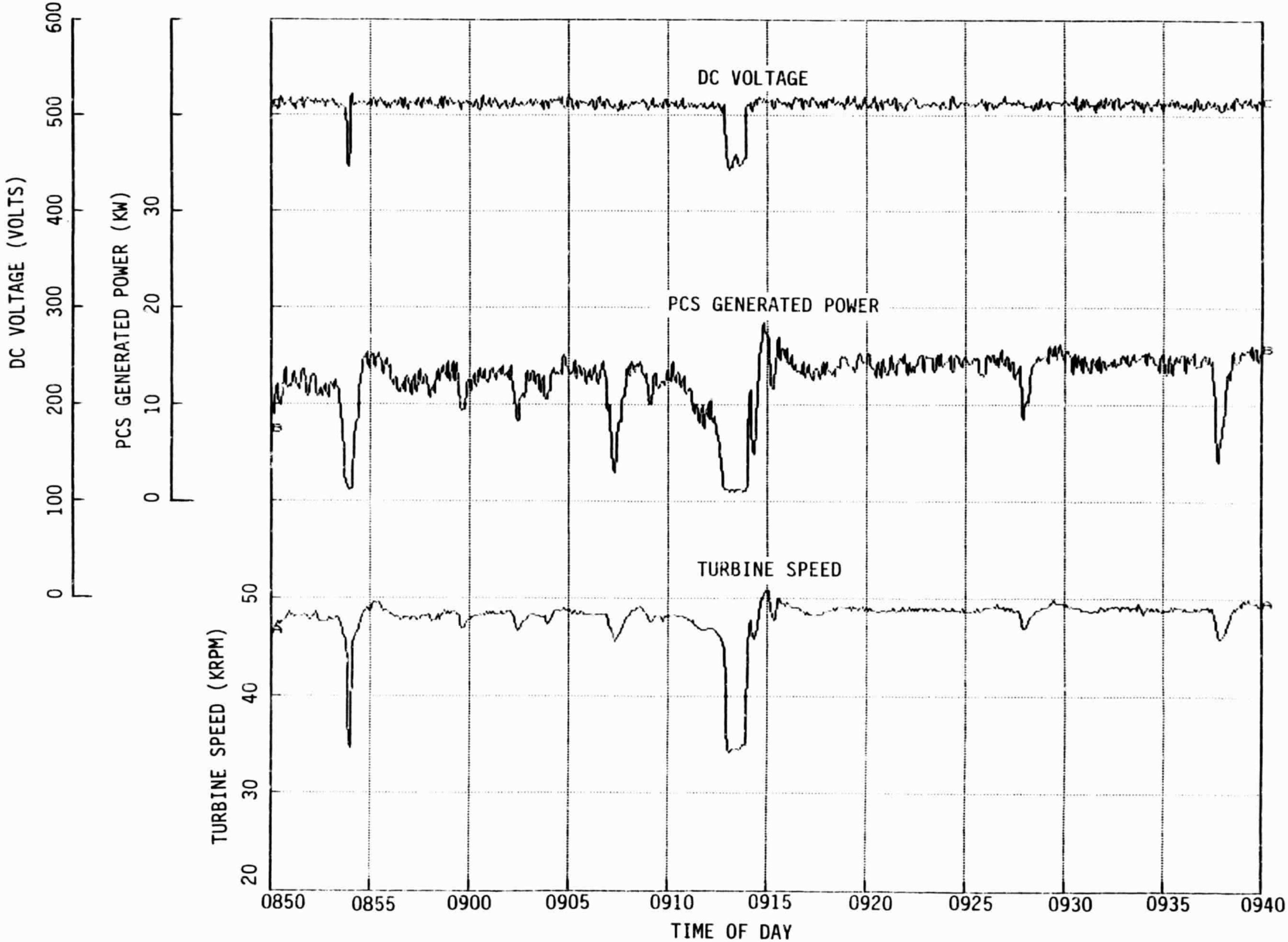

FIGURE 4-8. VOLTAGE/POWER/SPEED RELATIONSHIPS DURING A CLOUD PASSAGE (RUN 17, TEST NO. 12)

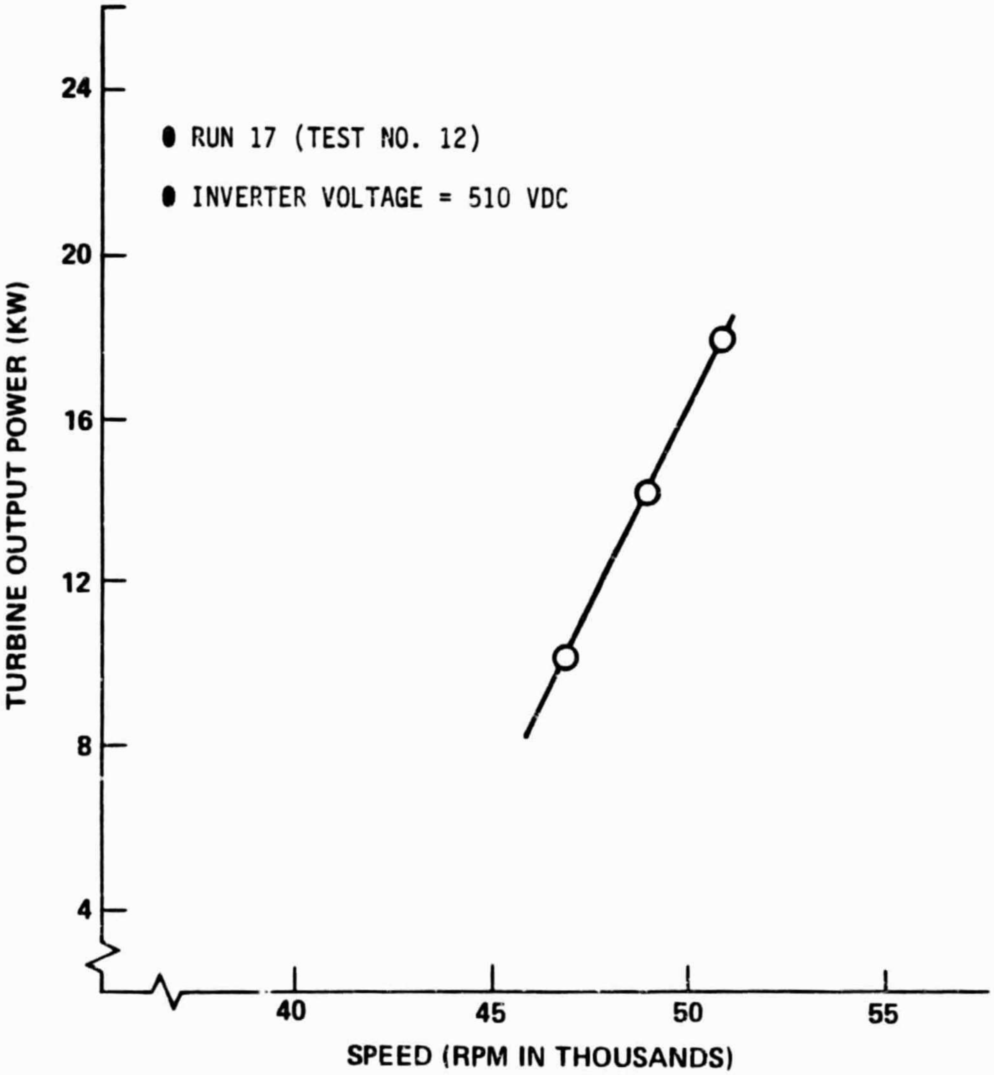

FIGURE 4-9. TURBINE/ALTERNATOR OPERATING SPEED CHARACTERISTICS (RUN 17, TEST NO. 12)

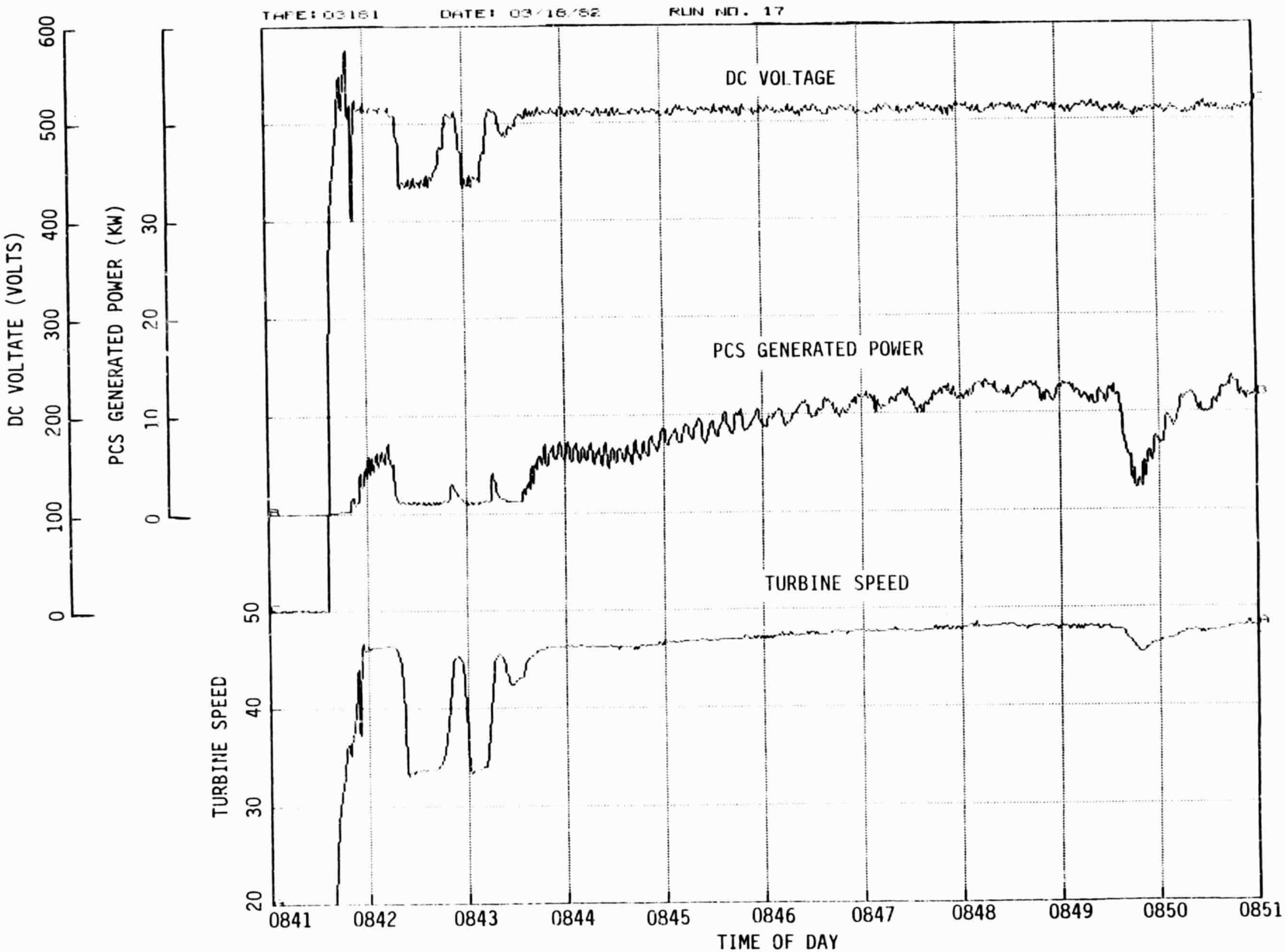

FIGURE 4-10. VOLTAGE/POWER/SPEED RELATIONSHIPS DURING START-UP FOR RUN 17 (TEST NO. 12)

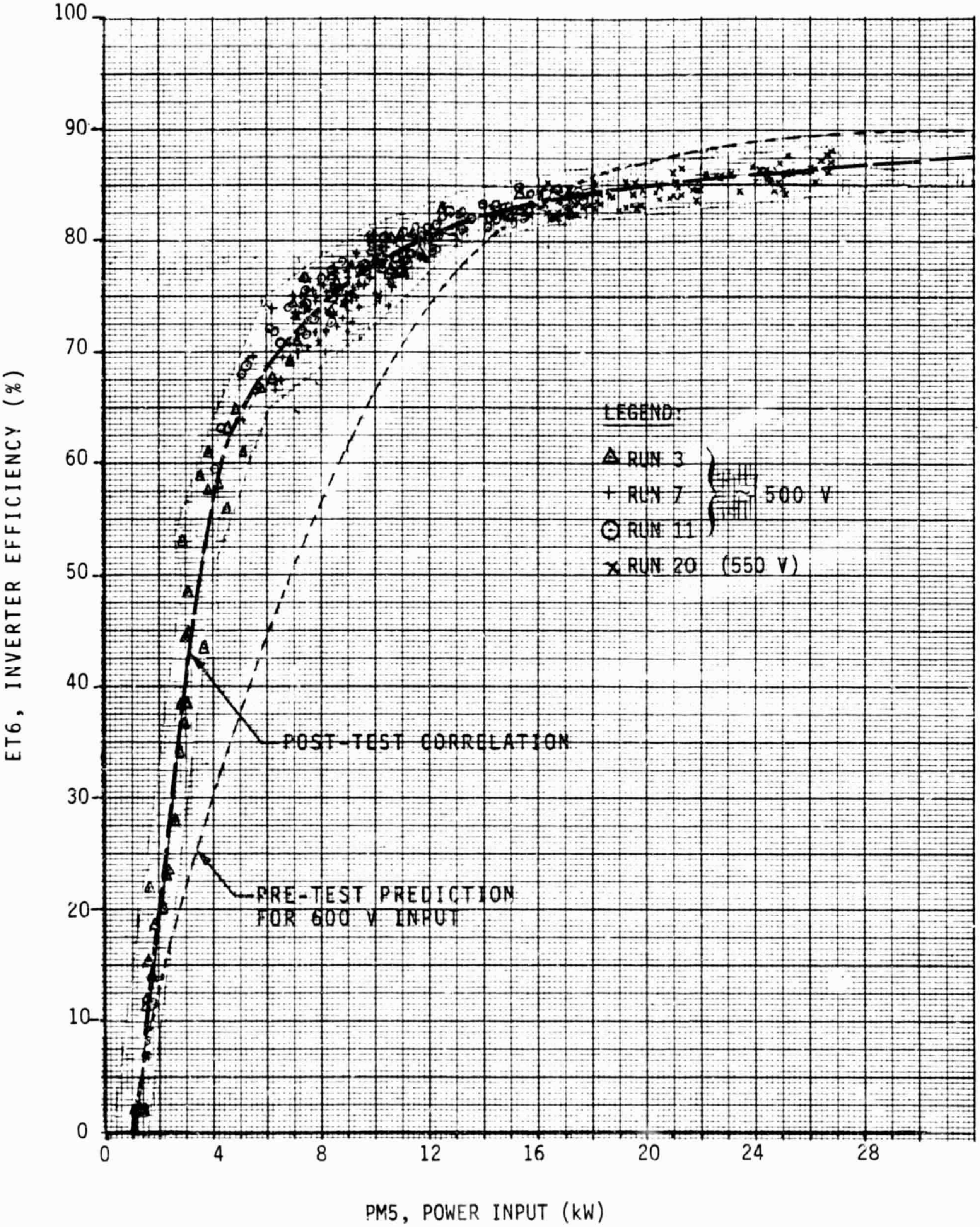

FIGURE 4-11. INVERTER EFFICIENCY DATA AND PRE-TEST PREDICTIONS

The data and other signals sent from the switchboard to the MPC are listed in Ref. 22 and summarized below.

- Current to inverter (dc)
- Voltage to inverter (dc)
- Inverter output voltage* (ac, 3 phases)
- Inverter output current (ac, 3 phases)
- Inverter output power factor* (phase 1)
- Inverter event status:
    - In/out of Phase
    - Off/on
    - Inhibit off/on
    - Power to load bank/grid
    - Load bank blower off/on

The ac voltage meters and power factor meter were not operating properly until after the tests were completed. Therefore, these readings for the grid-connected test (Run 21) were not correct.

4.2.5 CONTROL SUBSYSTEM

The plant control subsystem was designed with the capability of automatic, totally remote (unattended) operation of a future power plant in the 250 to 1 MW_e range. The use of only one module at the PDTS meant that not all the functions were implemented, but the capability for growth was provided. The subsystem was designed to make each power module relatively self-sufficient by providing it with its own processor called the Remote Control Interface Assembly (RCIA). The RCIA controls all the functions of its power module including closed-loop control of the vapor valve, start-up/shutdown procedures for the PCA, PCA data collection and monitoring, and, in the future, control of the concentrator. The MPC provides the operator interface and controls the overall operation by sending high-level commands to each RCIA (one for these tests). Other elements of the subsystem are the data link and the instrumentation. Additional subsystem description is contained in References 17 and 18.

*Valid only for grid-connected mode.

The principal tasks performed by the Control Subsystem computers at the PDTS were to:

a. Collect, display and record data,

b. Allow manual mode control of the PCS at operator's discretion,*

c. Generate the discrete commands to start, stop and operate the PCS,

d. Generate vapor valve commands to control the toluene working fluid temperature, and

e. Monitor the operation of the hardware and take appropriate action if anomalies were detected.

4.2.5.1 Data Handling. The collection and display of data proved to be an adequate and convenient aid to the operator in realtime monitoring of the system performance. Playbacks of data recorded by the system were used extensively, and many examples are included in this report. Both the printed and plotted format of these data have proven invaluable in evaluation of the tests.

4.2.5.2 Operator Control. The option to use the manual control mode capability gave the operator a high degree of flexibility over the PCS operation, if desired. The repertory of available mode commands was expanded as the testing progressed, and proved to be useful in dealing with abnormal or unexpected situations. In future tests it is expected that the software will include logic to deal with all contingencies, and the manual mode control functions will be eliminated or rarely used.

The PCS mode control functions available to the operator were:

- PCA TEST ON/OFF. Initiate pump start procedure.

- PCA COOLDOWN ON/OFF. Flow fluid without spinning turbine.

- SPEED CONTROL ON/OFF. Turbine speed control mode.

- HIGH POWER ON (or HEAT DISSIPATION). Force wide open valve command (clear with FAULT RESET).

- DETRACK. Close sliding plate.

- EMERGENCY SHUTDOWN. Close sliding plate and shut engine down.

- FAULT RESET. Clear faults and warning flags.

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*There was also the option of taking over complete manual control using the B-N panel at the base of the concentrator, but this was not necessary since the available control options were adequate.

- START. Force turbine start.

- PCA ON/OFF. Enable startup sequence.

4.2.5.3 PCS Control Sequence. The normal PCS startup sequence that was used during testing was:

(1) The Operator keyed PCA TEST ON and PCA COOL DOWN ON functions. This verified all components including pumps, fan, vapor valve and instrumentation were functional. When these items were verified, the operator keyed PCA TEST OFF which turned the pumps and fan off and returned mode to POWER OFF.

(2) The operator keyed PCA ON. This enabled the software to begin the startup sequence when a temperature rise occurred. No further manual control was necessary past this point except for mode testing, some emergency conditions, or to key PCA OFF at the end of a run.

(3) The concentrator was brought onto sun track and the sliding plate was opened.

(4) When a rising temperature in the receiver shell was detected by the RCIA, the boost pump, start pump and fan were sequentially turned on and the vapor valve was enabled. The valve was opened only as required to prevent the receiver pressure from exceeding 750 psi.

(5) When the receiver shell temperature (RCSTP5) reached 580°F, the turbine was started by the RCIA commanding the valve to 40 percent open.

(6) When the turbine speed reached 35 krpm, NORMAL control mode was begun.

Normal shutdown was initiated by keying PCA OFF and closing the sliding plate. The normal control law continued until the receiver outlet (toluene) temperature dropped below 550°F at which time the engine was shut down.

The operational procedures and the software logic to perform these functions were refined during the process of performing the tests. In the final configuration, the software successfully controlled the PCA under all situations that were encountered without operator actions beyond the procedural items outlined above.

One area of concern in the startup procedure was the possibility of spinning the turbine while cracking ("burping") the valve to prevent receiver overpressure. Since it was potentially damaging to the bearings to rotate at relative low speeds (below ~20,000 rpm), logic was incorporated into the software to initiate a start if the turbine began spinning even though the normal start temperature had not been reached. (It has not been conclusively determined whether or not there may be conditions where the turbine can be caused to spin by the pressure relief process, but where turbine operation cannot be sustained.)

4.2.5.4 Vapor Valve Control Law. The primary task of the vapor valve control law was to control flow (power) to the turbine so as to keep the toluene temperature at the receiver outlet at a constant temperature of 750°F. A simplified block diagram of the control law which was used to do this is given in Figure 4-12. As shown in the figure, the inner loop controls the receiver shell temperature, RCSTP5, and has a control time constant of about 10 seconds. This loop drives the shell temperature to a value, SETPT, which is determined by the outer loop which has a time constant of about 6 minutes.

A sample startup transient is shown in Figure 4-13. The sliding plate was opened at 13:06 and the turbine was started at 13:10. The receiver outlet temperature was above 700°F within 3 minutes although the system was not well stabilized until about 20 minutes after the start.

As the input power decreases (i.e., cloud passage) the vapor valve closes to try to keep the receiver fluid exit temperature at 750°F. If the input power drops too low the output voltage will go below the control voltage of the inverter while the turbine speed continues to drop.* The control law then changes to a speed control loop. This is referred to as minimum speed valve command limit (IDLE mode) and the turbine speed will be kept at ~35 krpm. When the input power returns, the temperature rises and the control law returns automatically to the temperature control. An example demonstrating this action is shown in Figure 4-14 where a cloud passage was simulated by closing the sliding plate for 4.5 minutes (Run 13, Test No. 8). During the time the valve command was on the minimum speed limit, the temperature dropped because energy was still being withdrawn and the heat input was zero. During this time the control variable SETPT was ramped down so as to prevent a temperature overshoot when the power returned. When the sliding plate opened, the temperature began rising, and within about 5 minutes the major part of the transient was over. The receiver temperature and valve position for this same run are shown in Figure 4-15.

The control law logic software was modified and refined several times before the final configuration was reached. A representative plot for each test is shown in Appendix A (i.e., receiver outlet temperature, valve position and insolation). Some of the early tests show receiver outlet temperature overshoots and other undesirable characteristics which were eliminated in later runs. Runs 9 and 11 (Tests No. 5 and 6) had some very oscillatory responses which were the result of intentionally varying control gains to determine system parameters.

Run 13 (Test No. 8) had a temperature overshoot to about 790°F after a plate closure of 4.5 minutes (see Appendix A, Figure A-8, Event 3). At Event 7 the system was shut down, new EPROMS with software modifications to reduce the overshoot were inserted into the RCIA, and the run was continued. Event No. 10 in Figure A-8 was a repeat of the 4.5 minute door closure, and the results show the temperature overshoot was eliminated. This run is also shown in Figures 4-2 and 4-3.

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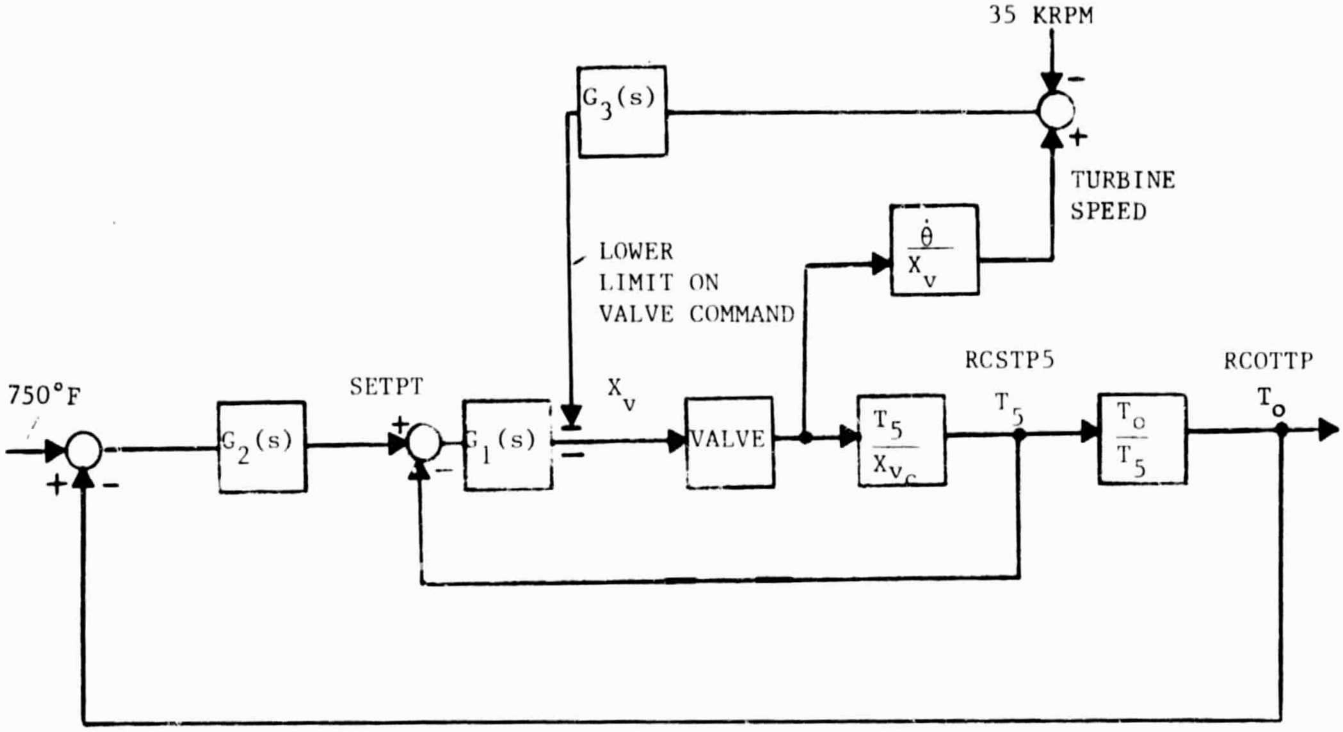
*A typical example was shown in Paragraph 4.2.4, Figure 4-8.



$$G_1(s) = \frac{1.5}{0.5\,s + 1}, \quad \%\ \text{VALVE}/°\text{F}$$

$$G_2(s) = .00153\ \frac{190s + 1}{s}, \quad \frac{°\text{F/SEC}}{°\text{F}}$$

$$G_3(s) = 0.4\ \frac{10s + 1}{s}, \quad \frac{\%/\text{SEC}}{\text{KRPM}}$$

FIGURE 4-12. VAPOR VALVE CONTROL LAW

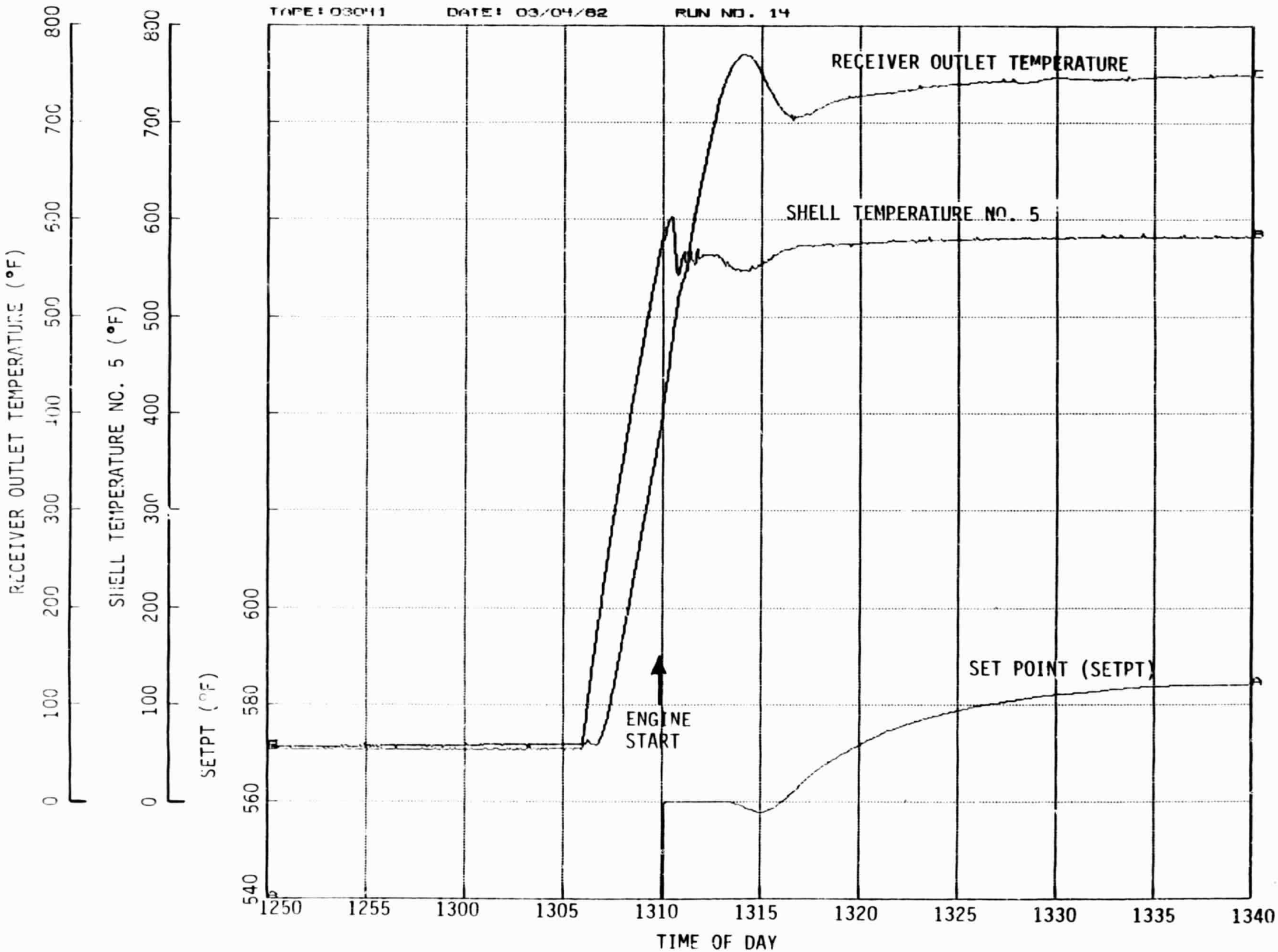


FIGURE 4-13. STARTUP TRANSIENT FOR RUN NO. 14 (TEST NO. 9)

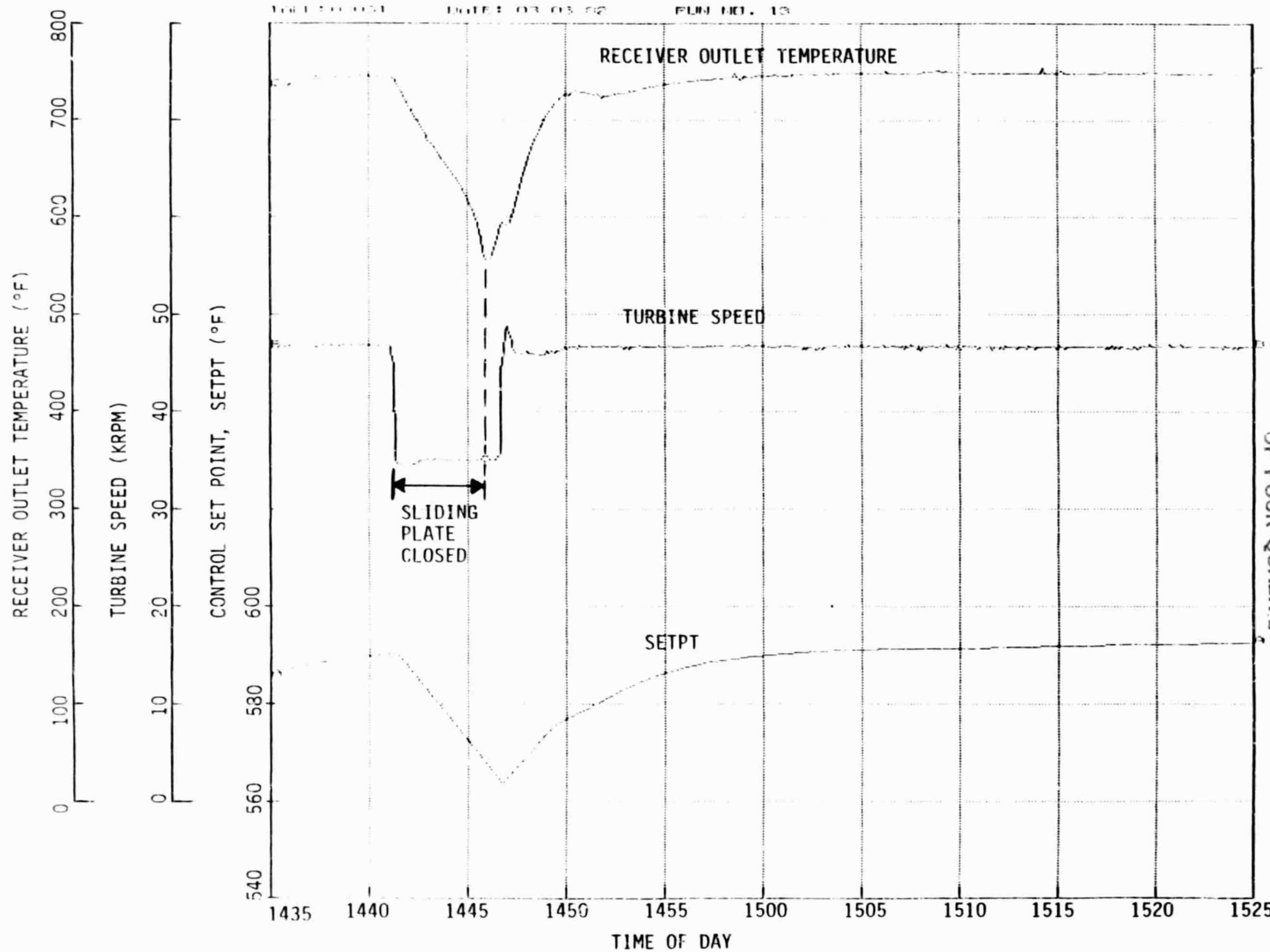


FIGURE 4-14. TRANSIENT INTRODUCED BY CLOSING THE SLIDING PLATE, RUN NO. 13 (TEST NO. 8)

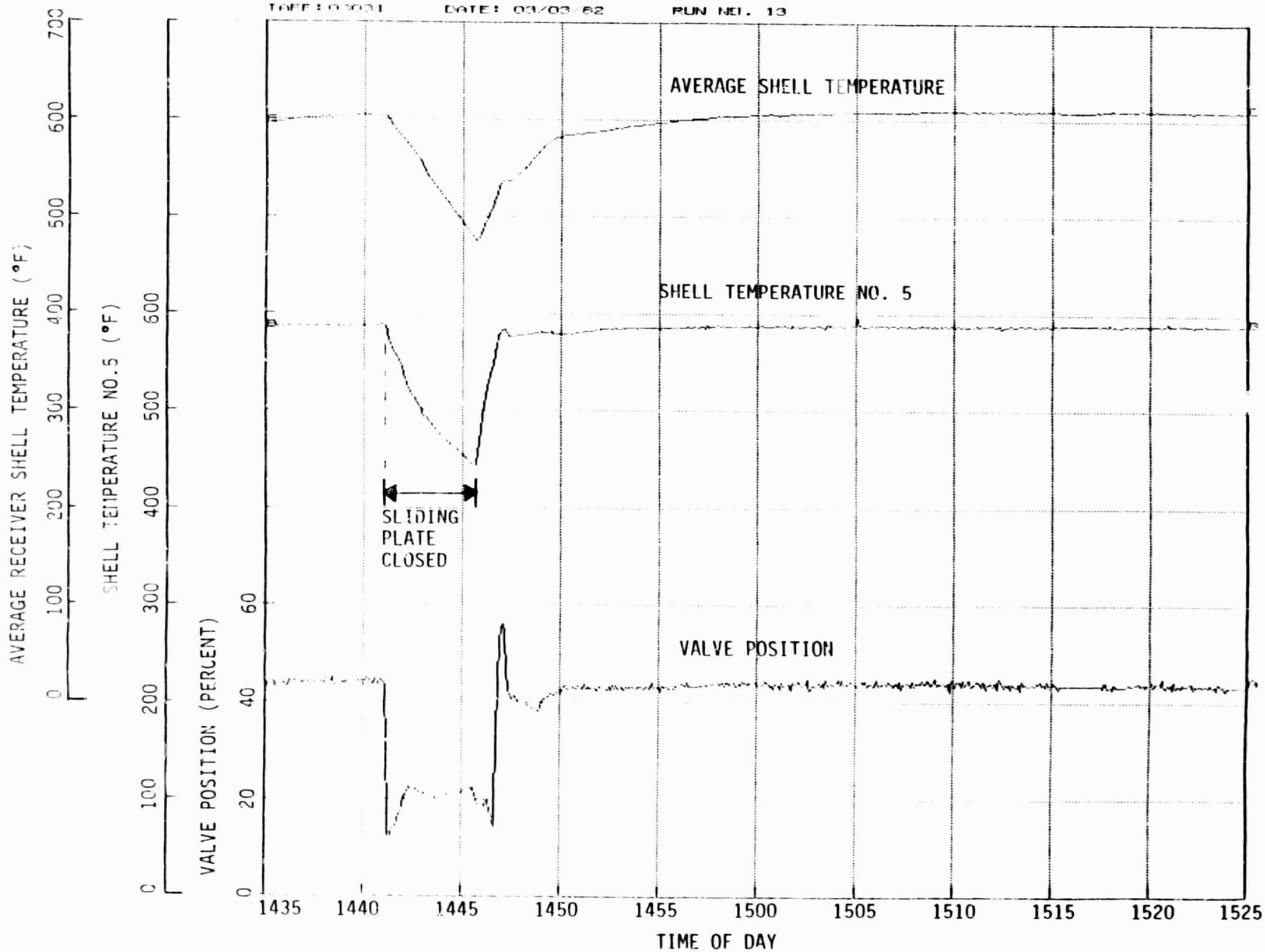


FIGURE 4-15. TRANSIENT RECEIVER TEMPERATURE AND VALVE POSITION CAUSED BY CLOSING THE SLIDING PLATE, RUN NO. 13 (TEST NO. 8)

A record of cloud passages for Run 17 is shown in Figure 4-16. The figure shows that the valve position responded to the insolation level changes by changing the power delivered to the turbine. Throughout the run, however, the toluene temperature at the receiver outlet was kept within about 20°F of the desired 750°F, even when the insolation dropped to one-third its normal level. Normally, the temperature was held within ± 5°F for short periods ($\sim$1 minute) of insolation levels as low as one-half the normal value.

4.2.5.5 Fault Logic. The control system (MPC and RCIA) collected a large amount of data and tests were devised to determine if the system was operating normally or if a problem existed for which some corrective action should be taken. This fault logic was modified and expanded by software changes during testing, and this process will be continued in the future. The logic currently in effect is summarized here, and has proven to cope effectively with all contingencies that were encountered at the PDTS.

When the turbine was running and an anamolous condition was detected, the possible actions of the computer were to do one of the following:

(1) Warning -- Set the PCA warning flag which displayed a messge on the CRT and sounded an alarm. Any action was at the discretion of the operator.

(2) Initiate Heat Dissipation Mode which consisted of:

a. Command DETRACK (i.e., close the sliding plate).

b. Set vapor valve command to 95 percent (i.e., high power setting to cool the engine down, HIGH POWER ON mode).

c. When the temperature dropped sufficiently perform a normal engine shutdown.

(3) Initiate Emergency Shutdown which consisted of:

a. Command DETRACK (close the sliding plate).

b. Command vapor valve closed.

c. Apply the brake.

The major categories of failures and the actions that were taken for each one are summarized in Table 4-3. The tests demonstrated that the best thing to do in the majority of fault situations was to continue running the engine to extract the residual heat from the system and prevent excessive temperatures and pressures rather than to shut it down hot. Emergency shutdown was therefore used only when a condition existed that would result in damage to the engine if the run were to continue. The HEAT DISSIPATION mode was a continuation of running the engine in a way that required a minimum amount of control information (data). If the HEAT DISSIPATION mode were to be initiated and the fault then disappeared (as for example an over-temperature), the operator

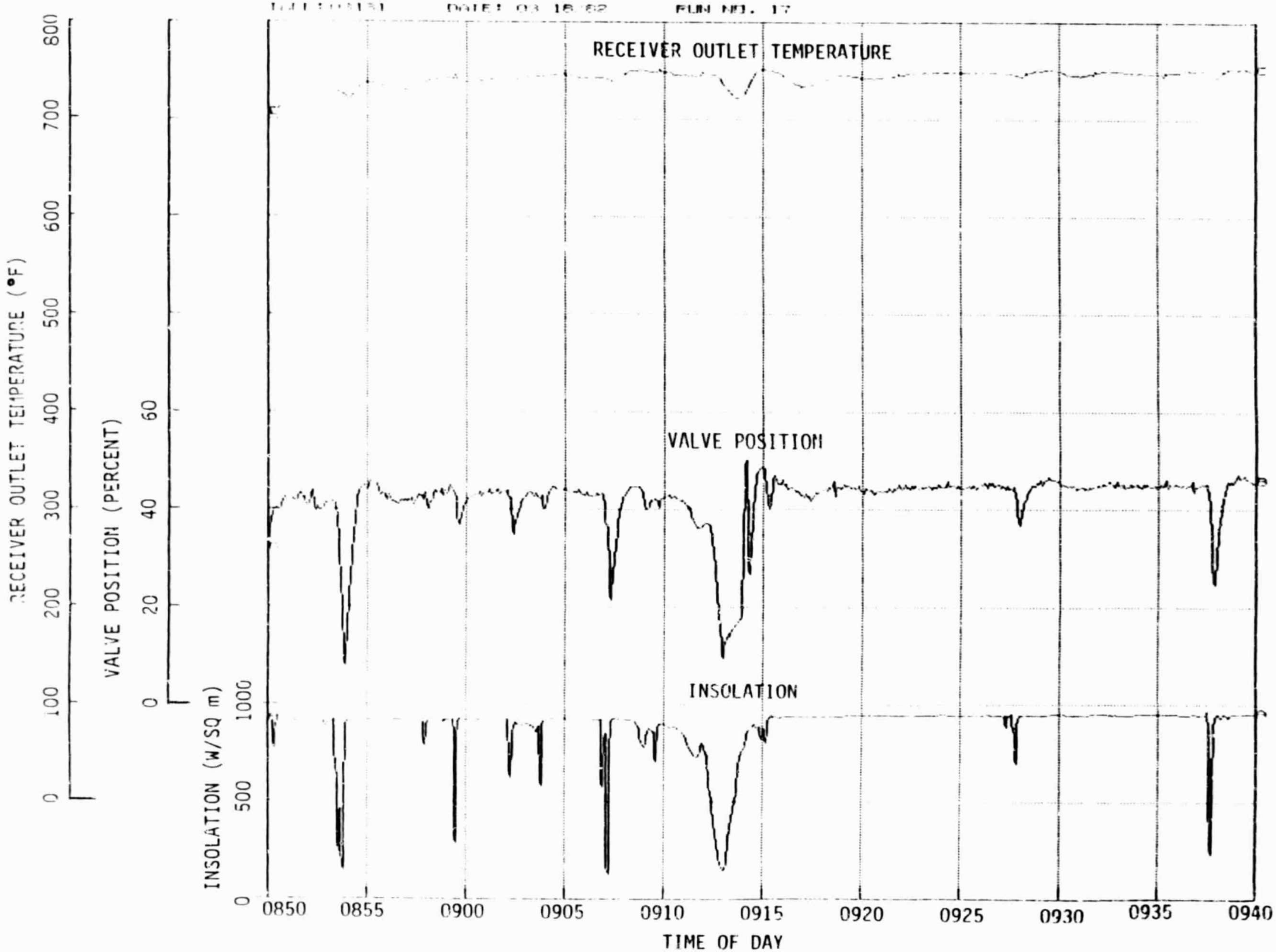


FIGURE 4-16. TEMPERATURE RESPONSE TO CLOUD PASSAGES, RUN NO. 17
(TEST NO. 12)

TABLE 4-3. COMPUTER ACTIONS IN RESPONSE TO FAULT CONDITIONS

Failure	Action
• Alternator over-temperature	Emergency Shutdown
• Condenser over-temperature	Emergency Shutdown
• Condenser over-pressure	Emergency Shutdown
• Receiver outlet over-temperature	Heat Dissipation
• Receiver outlet over-pressure	Heat Dissipation
• Receiver shell outlet over-temperature (RCSTP2)	Heat Dissipation
• Analog channel error - non-critical	Warning
• Analog channel error - critical	Heat Dissipation
• Discrete Functions:	
SYSH (brake applied)	Emergency Shutdown
BPDPL (boost pump press low)	Emergency Shutdown
SPDPL (system pump press low)	Emergency Shutdown
• RCIA Faults:	Emergency Shutdown
RAM check, Checksum, Data Link Error, Sync Error, Spurious Interrupt	

could clear the condition with a FAULT RESET and continue the run without shutting the engine down.

4.2.6 ADDITIONAL TEST FINDINGS

This paragraph summarizes miscellaneous items not covered elsewhere in this report that were found during the course of testing at the PDTS. These should be considered for future effort, especially for Small Community Power Plants.

(1) Bird Nests. Birds, specifically starlings, found the receiver and the hollow space above the regenerator a desirable location for nests. The receiver was cleared several times of sticks and other materials that were carried in over a weekend or after the end of a workday. A nest inside the receiver would burn and possibly cause damage due to smoke or flames. Access to the space above the regenerator was much more restricted, and a large, complete nest (with eggs) was found when the unit was removed from the TBC. A nest in this region would probably not be serious unless heated sufficiently to catch on fire. It will be comparatively easy to screen this region from birds, but the receiver is another problem since the

aperture region must be open. Also it is likely this problem will be restricted to the spring months when nest-building takes place.

(2) Accessibility. Considerable time can be saved by making high-maintenance items such as filters, electrical connections, data transmitters, sensors, etc., easy to reach and service. The present PCA is poor in this regard - primarily due to the condenser and support structure location - but can be greatly improved by moving some items or providing access doors. The use of a water-cooled condenser would greatly reduce the volume and provide greatly improved access.

(3) Filters. The 10-micron filters for the valve actuation flow and the start pump proved to have too small a capacity. Also the valve filter was probably too coarse, and a new, high-capacity, three-micron filter was obtained as a replacement. Both filters will be replaced and relocated for accessibility before the next test series. The large filter used for the main flow proved to be adequate and will not be changed.

(4) Accumulators. The two bladder-type accumulators worked well throughout the tests. However, there was a question as to the compatibility of the bladder material with toluene and possible fluid contamination, so piston-type units are being considered as possible replacements.

(5) Toluene Drain. The toluene drain plug was not located at the bottom of the hot well; therefore, it proved to be nearly impossible to drain all the fluid from the unit. This plug will be relocated in any future redesign, and a better means of draining the fluid from the lines provided.

4.3 SYSTEM PERFORMANCE

The individual component and subsystem efficiencies and performance that were obtained during the verification tests have been combined to yield "module" and "overall" values. The term "module" refers to the power out of the PCS, i.e., module efficiency is PCS power out (PM5 in Program OPWEG) divided by the power available to the concentrator for focusing. "Overall" or "system" refers to the power out of the inverter (PM6); thus, overall efficiency is PM6 divided by available power to the concentrator.

The example selected as representative of a typical steady-state condition was Run 13 (Test No. 5) at 12:00 noon. This test was conducted on March 3, 1982 and had a total run time of 6.7 hours. A data print-out for a short period after noon for Run 13 is given in Appendix B, and sample plots are given in Figures 4-2, 4-3, 4-6 and A-8. The solar insolation from the Eppley pyrheliometer at 12:00 was 983 W/m^2, but that available for focusing was 3.5% less due to the average circumsolar effect described in Paragraph 4.2.1 and Reference 23. Thus, the power available for focusing was:

$$(983)(0.965)(87.6)/1000 = 83.1 \text{ kW},$$

where the term 87.6 is the effective area of the concentrator in square meters. The value of 83.1 kW is the first step on a waterfall-type performance chart in Figure 4-17. This figure also shows the efficiency of the individual components and subsystems. The values used were primarily obtained from the output of Program OPWEG (see Appendix B, Table B-1) by the techniques summarized below; additional details are contained in Reference 23.

- The efficiency of the concentrator, η_{CONC}, was obtained from the product of the reflectivity, dust and blockage factors listed in Paragraph 4.2.1. The updated blockage ratio of 0.967 was used.
- The receiver efficiency, η_{RCVR}, was obtained by averaging the "measured" efficiency from the program print-out (EM4*) over a period of about 30 seconds before and after noon.
- The PCS and inverter efficiencies (EM5 and EM6 in Program OPWEG) were obtained by averaging the outputs from the program over the intervals described above.

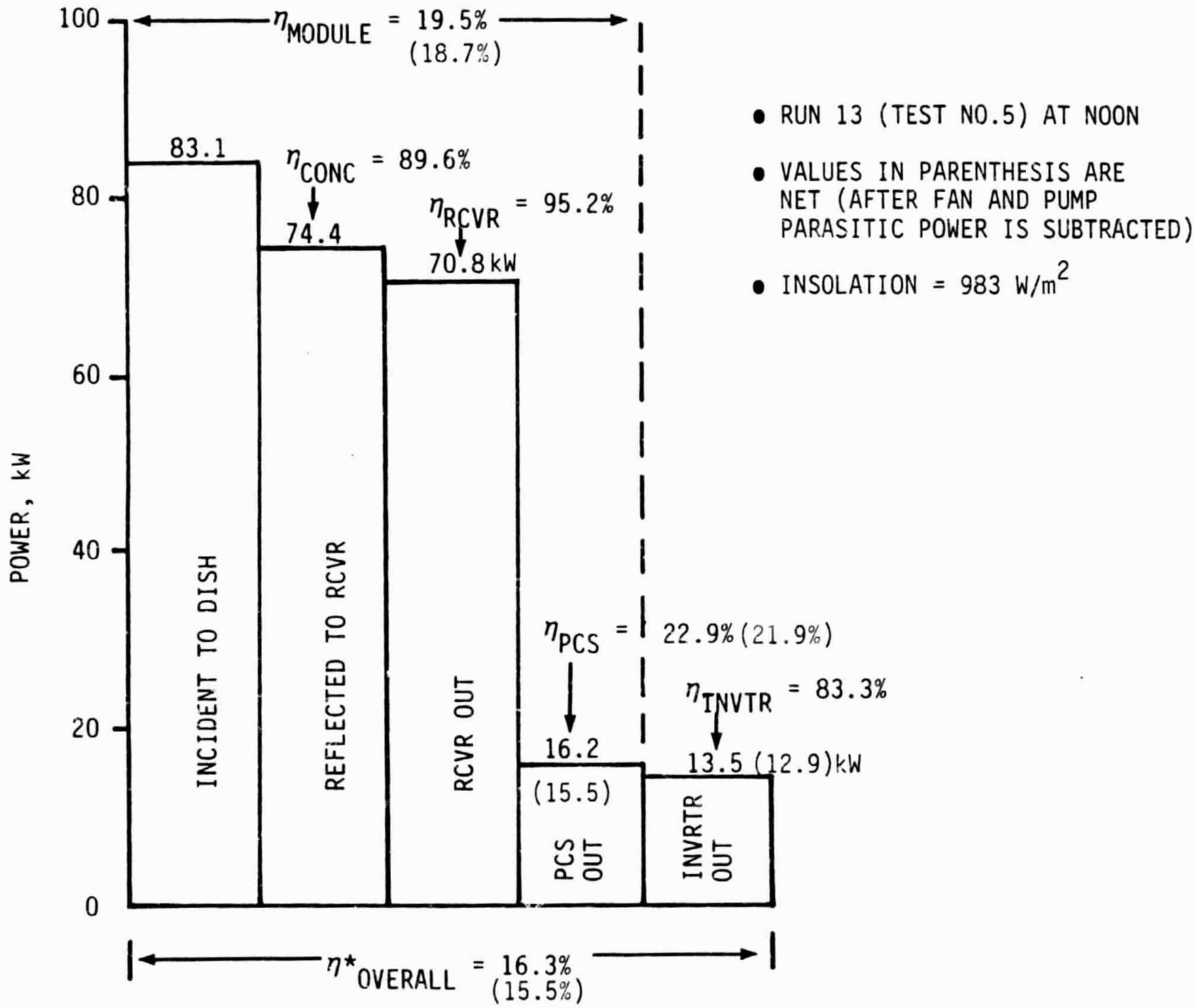
Numbers in parentheses in Figure 4-17 refer to net values; that is, they have the PCS parasitic power of 0.68 kW for high-speed fan conditions accounted for. For example, the module efficiency for the conditions noted was 19.5 percent measured or gross, or 18.7 percent net. The module (PCS) power output was 16.2 kW gross, or 15.5 kW net.

The overall or system efficiency was 15.5 percent (net) or three points less than that for the module due to the losses through the inverter (83.3 percent efficient). As described in Paragraph 4.3.4, the inverter was a subscale unit (30 kVA, rated) and operated at an input dc voltage for this test of ~500V, compared to a design value of 600 V. Both of these factors reduce the efficiency that could be obtained with a larger unit operating at a higher voltage.

Figure 4-17 also shows all the components in Test 13 were operating well below design power levels, even though the insolation was only about 10 percent below the peak rated value (983 vs 1100 W/m^2). The primary reason for the relatively low power output was that the TBC is not large enough to provide the design power inputs, and thus the higher component efficiencies associated with them. The following comparison illustrates this fact.

Component/Subsystem	Input Power for Run 13 (kW)	Design Input Power (kW)
Receiver	74.4	95
PCS	70.8	92.4
Inverter	16.2	30 kVA rated, 40 kVA peak

*The values for EM4 in Table B-1 of Appendix B must be increased by 5.5 percent to correct for the erroneous value for the concentrator effective area that was used until Run 16.



*INCLUDES SUBSCALE INVERTER

FIGURE 4-17. MEASURED COMPONENT, MODULE AND SYSTEM PERFORMANCE FOR A TYPICAL RUN

As seen in this comparison, the PCS was operating about 30 percent below the design power level and is the component which is most sensitive to part load performance penalties. Therefore, the 22 to 23 percent efficiency of the PCS for this run is not unexpected, especially when the off-design considerations discussed in Paragraph 4.2.3 are included.

SECTION 5

CONCLUSIONS

The PDTS tests demonstrated the high potential of the Small Community Solar Power concept. The tests established a number of 'firsts' or milestones, for example:

- The first ORC engine to be powered by a parabolic dish concentrator.
- The first demonstration of the use of an automatic plant control by the use of a local computer (the RCIA) for control of the engine, transmitting data to and commands from a central computer (the MPC).
- The use of toluene as the working fluid for a dish-mounted system.
- The use of a control-type inverter which maintained the input (dc) voltage within narrow limits, thus providing load control for the turbine/alternator/rectifier.
- Automatic data logging of all instrumentation and performance channels (93 total) at one-second intervals.

The wide range of conditions that were tested covered the planned spectrum. The excellent performance of the control subsystem in achieving stable, controllable and safe operation of the SCSE hardware was one of the major achievements of the tests. The two key control parameters - fluid outlet temperature and dc voltage - were held within one or two percent for normal operating conditions.

It was demonstrated that the inverter could control the voltage (load) from the output of either one or two sources; in the latter case the first source was the PCS and the second was the simulated output from another PCS using the Nova dc power supply. The inverter supplied the output power to a resistance load bank for most of the tests. The use of the grid as the output of the inverter for one test demonstrated successful operation, however the inverter control circuits must be modified slightly so that the output switches to the load bank whenever the power reaches a low level, rather than to the "INHIBIT" mode as it did during the initial on-grid test run.

Efficiency of various components was about as expected for the (limited) output of the Test Bed Concentrator. The receiver performance was outstanding, being over 95 percent for most of the tests. The copper walls had about four minutes worth of "buffer" storage of thermal energy and showed no evidence of hot spots or instabilities due to two-phase (subcritical) flow. The ORC engine (PCS) had a net efficiency of approximately 22 percent at an input power of 70.8 kW_t. The PCS operated most efficiently at an output of around 500 Vdc, which is considerably below the original design value of 600 Vdc. Recommendations to improve the voltage (and other aspects of the performance) have been

made and are planned to be implemented in the future. The ultimate goal is to reach a PCS efficiency of approximately 26 percent at the conditions defined above.

The minimum solar flux for sustained operation was about 300 W/m^2, or 23 kW_t at the receiver aperture. No problems were experienced in operating over variations in solar insolation ranging from full sunlight (>900 W/m^2) to high overcast (~300 W/m^2). The most severe transients were deliberately caused by periods of door closures, but again stable control was always achieved.

The inverter efficiency was 83.3 percent at an input power of 16.2 kW_e and voltage of 500 Vdc. This value is close to pre-test predictions for a subscale inverter of this type. Increasing the input voltage to the design value of 600 Vdc should improve the performance of the present inverter by about two points. As stated previously, the load control function of the inverter was excellent during normal operation to a load bank. The grid-connected operation will be extensively tested during the next test series, after minor modifications are made to a control circuit.

The net overall end-to-end efficiency (sun in to inverter ac power out) was 15.5 percent (after PCS parasitic losses are subtracted), or 16.3 percent gross (parasitic losses not subtracted). These values are based on an input power of 83.1 kW_t incident on the TBC, which is close to the maximum reached during these tests.

The PDTS tests demonstrated that the elements of the SCSE system performed as designed. The completely autonomous plant control sybsystem being developed should have very broad applications in future solar plants regardless of the type of heat engine or point focus concentrator employed.

SECTION 6

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APPENDIX A

TEST EVENT SUMMARY AND SAMPLE DATA PLOTS

APPENDIX A

TEST EVENT SUMMARY AND SAMPLE DATA PLOTS

This appendix presents a table and a sample data plot for each PDTS run made during the February-March, 1982 time period. Each table has a statement of the purpose of the test and a log of the major events which occurred during the run. Pre- and post-test notes are also given as to the status of the test hardware or software.

Each of the events listed in a table are identified on the corresponding figure by a circled number at the appropriate time during the test. Each figure contains the time history of the raw data for receiver (fluid) outlet temperature, valve position, and solar insolation. The event marker shows what effect, if any, the event had on outlet temperature and valve position. (As stated in Paragraph 3.3, the valve was controlled during normal operating conditions to hold the receiver outlet temperature at 750°F while maintaining the receiver wall temperature (RCSTP5) and turbine speed within limits.) The insolation data were obtained from the Eppley pyrheliometer mounted directly to the concentrator*, i.e., readings were obtained only during the time the concentrator was "on-sun."

The runs presented in this Appendix are given in chronological order, for example, Table A-1 and corresponding Figure A-1 contain the results for Run 3 (Test No. 1) which was the first engine start-up. The final test was Run 21 (Test 16) shown in Table A-16 and Figure A-16.

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*The Eppley was mounted to the concentrator for Run 7 and subsequent runs. The earlier runs used the local Eppley located south of TBC-1.

TABLE A-1. TEST EVENT SUMMARY: RUN 3 (TEST 1), FEBRUARY 8, 1982

Purpose: Initial check-out with 25% masking

Event Log:*

Event	Time	Description
1	13:12:40	Open sliding plate or door (not shown on figure)
2	13:23:42	Engine start
3	13:24:45	Heat dissipation mode due to receiver outlet over-temp
4	13:24:56	Normal shutdown due to erroneous indication of cool turbine inlet temp
5	13:28:05	Engine start
6	13:28:30	Open sliding plate
7	13:29:12	Heat dissipation mode due to receiver outlet over-temp
8	13:31:06	Fault Reset
9	13:31:48	Shutdown

POST-TEST NOTES:

- The over-temperature problem was due to RCSTP5 temperature sensor erroneously indicating a lower then actual temperature.
- After the test TRINTP and RLEXTP sensors were inoperative.

*See accompanying figure for the effect, if any, of these events on valve position and receiver outlet temperature.

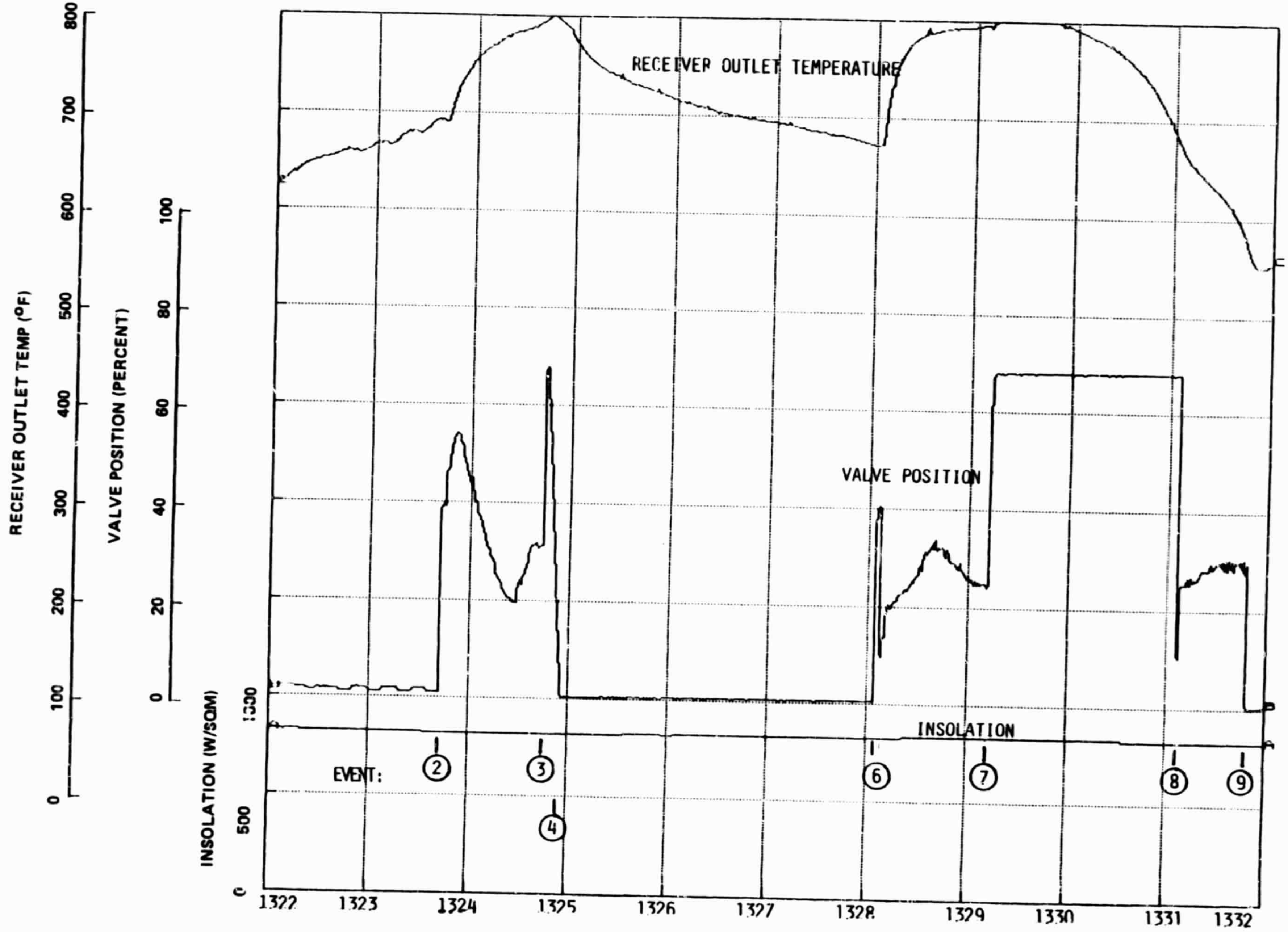

FIGURE A-1. SUMMARY PLOT FOR RUN 3 (TEST 1)

TABLE A-2. TEST EVENT SUMMARY: RUN 5 (TEST 2), FEBRUARY 11, 1982

Purpose: Control system and component checks with 25% masking

PRE-TEST NOTES:

- Temperature sensors RCSTP5, TRINTP and RLEXTP were fixed and verified.
- Bias was added to vapor (turbine) control valve command to ensure complete closure.

SEQUENCE OF EVENTS:

Event	Time	Description
1	13:10:00	Open sliding plate (door)
2	13:16:48	Engine start
3	13:34:30	Open by-pass valve
4	13:36:30	Shutdown due to "A/D CAL ERROR" - cause unknown

POST-TEST NOTES:

- Threshold in by-pass valve logic had to be changed to cause the by-pass valve to close.
- After run RLEXTP sensor was bad.
- After shutdown, a re-start was attempted, but the vapor (control) valve failed to respond to commands.

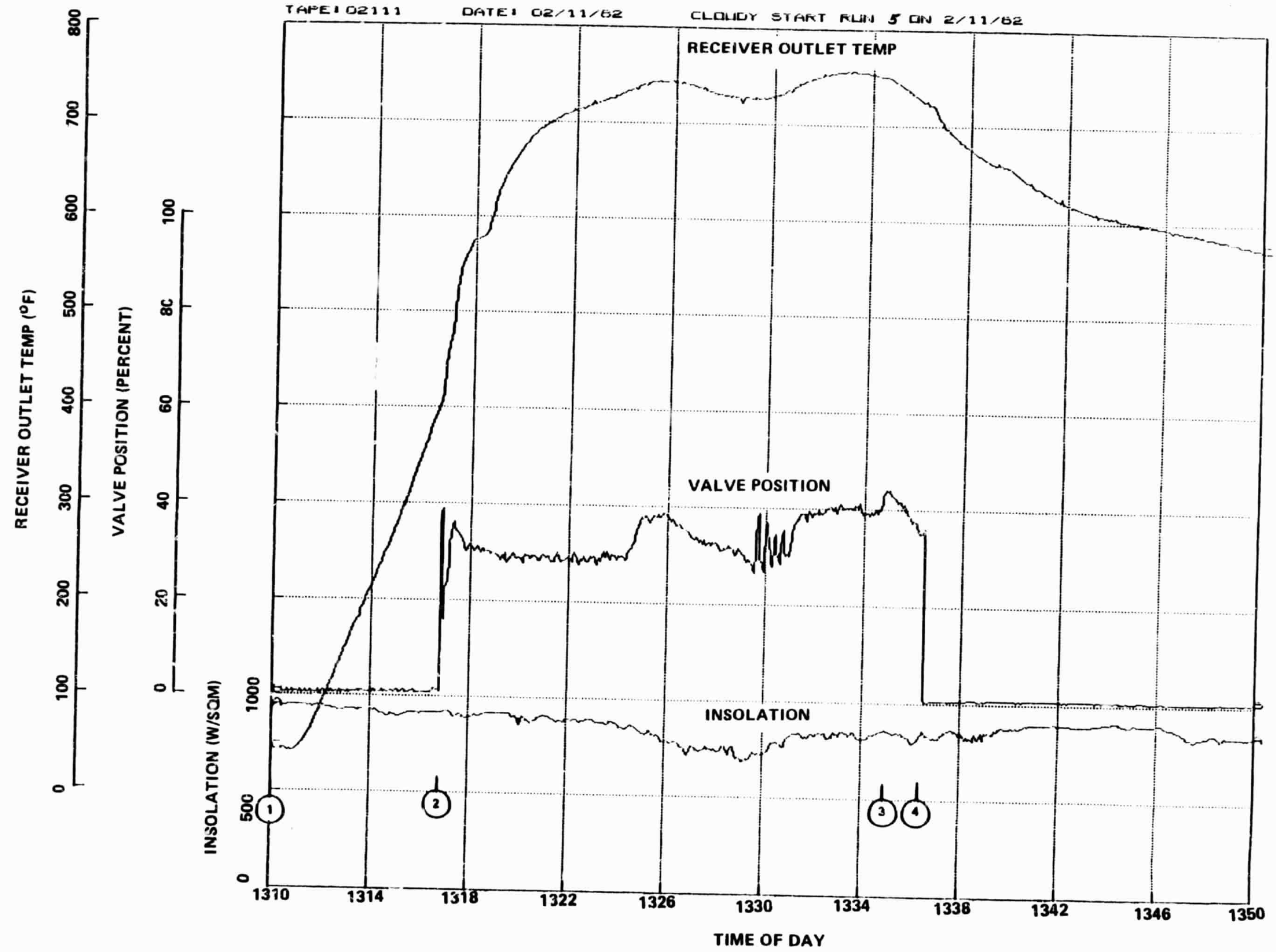

FIGURE A-2. SUMMARY PLOT FOR RUN 5 (TEST 2)

TABLE A-3. TEST EVENT SUMMARY: RUN 7 (TEST 3), FEBRUARY 23, 1982

Purpose: General operating experience and response to door closures, inverter voltage levels and check-out of speed control mode for 25% masking

PRE-TEST NOTES:

- PCA was removed from concentrator and the Moog valve driver replaced and all filters cleaned. Unit was remounted and checked out.
- Spade lugs were put on wires in JB-12.
- CNEXTP RTD was replaced.
- All toluene was replaced. A cold trap was used on the vacuum pump for the first time.
- A/D cal fault tolerance was increased from $\pm 3\%$ to $\pm 10\%$.
- By-pass valve logic levels were changed.
- Shutdown keyed to RCOTTP rather than TRINTP.
- The block valve closed for 3 seconds during the startup sequence to ensure pressure buildup to close the vapor valve.

SEQUENCE OF EVENTS:

Event	Time	Description
1	10:02:50	Open sliding plate (not shown on plot)
2	10:12:00	Engine start
3	12:47	Increase inverter dc voltage from 525 V to 560 V
4	13:33	Decrease voltage to 500 V
5	14:02:30	Speed control mode for 1 minute
6	14:08:30	Speed control mode for 45 seconds
7	14:16:00	Close door for 30 seconds
8	14:27:00	Close door for 1 minute
9	14:41:30	Close door for 1 minute
10	15:02:30	Close door for 2 minutes

TABLE A-3. TEST EVENT SUMMARY: RUN 7 (TEST 3), FEBRUARY 23, 1982 (Continued)

SEQUENCE OF EVENTS:

Event	Time	Description
11	15:17:15	Close door for 5 minutes -- shutdown and restart
12	15:29:30	Close door (PCA ON)
13	15:32:40	Normal shutdown

POST TEST NOTES:

- RLEXTP sensor was bad for a time during the test and then recovered.
- Turbine speed sensor apparently reading high, see Run 9.

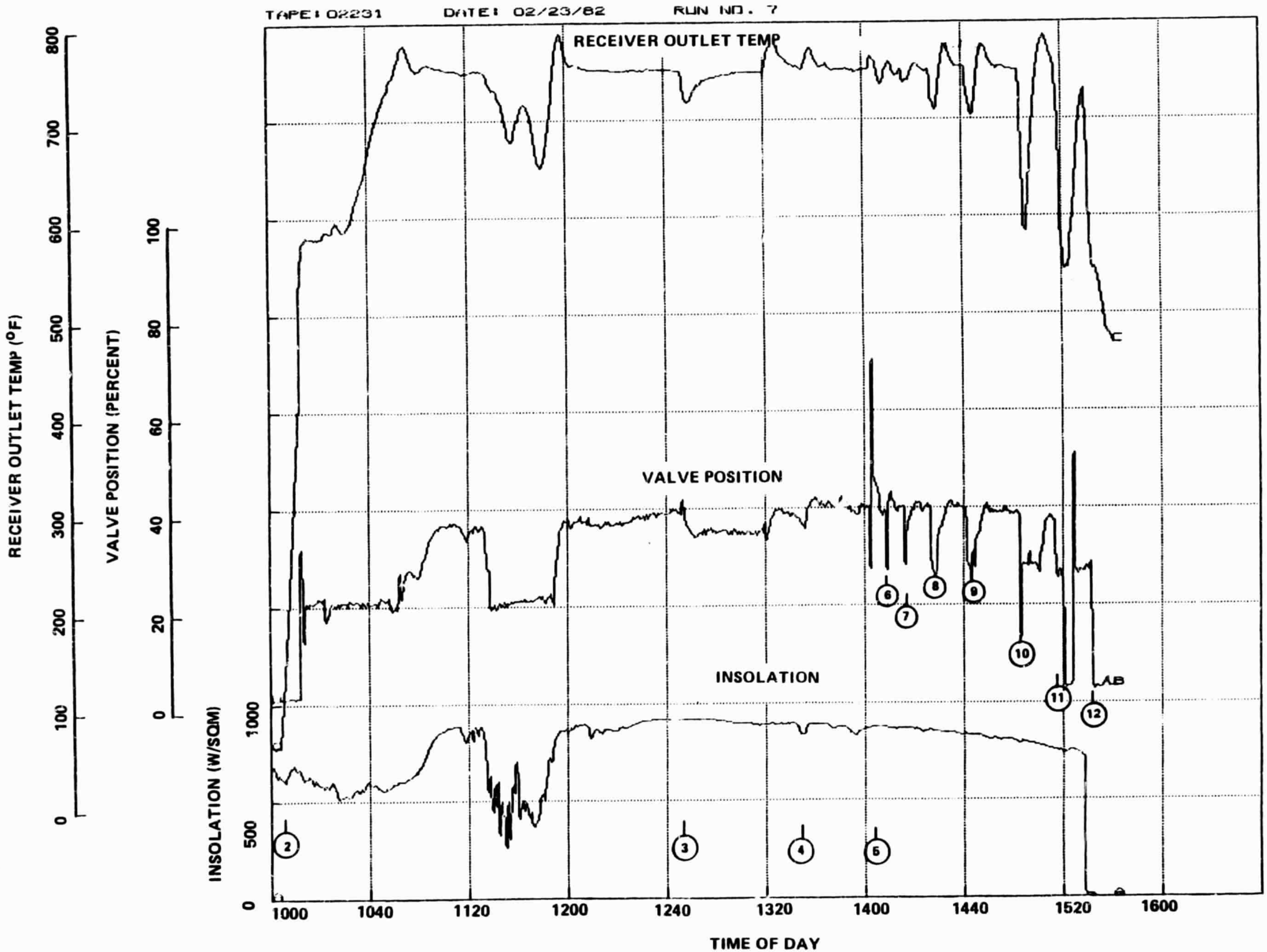

FIGURE A-3. SUMMARY PLOT FOR RUN 7 (TEST 3)

TABLE A-4. TEST EVENT SUMMARY: RUN 8 (TEST 4), FEBRUARY 25, 1982

Purpose: Verify operation with variable cloud cover with no masking

PRE-TEST NOTES:

- All covers removed from mirrors.
- Control law change implemented to zero integrator gain when the valve command reached a limit.
- The fan speed routine deleted so the speed can be selected manually (default is high speed).

EVENT LOG:

Event	Time	Description
1	08:35	Open sliding plate (not shown on plot)
2	08:47:07	Engine start
3	08:56	Normal shutdown (low insolation)
4	09:07	Engine start
5	10:10	Receiver overtemp -- door closed
6	10:11	Re-open door
7	10:18	Indication of receiver overtemp due to faulty sensor reading. The door closed automatically, and the engine was allowed to run at max power until normal shutdown occurred.

POST-TEST NOTES:

- On March 3, 1982 (see Run 13) software modifications were made to prevent receiver outlet temperature overshoot as on Event 5.
- At event 5, the over-temperature indication caused a 95 percent valve command. The valve responded by opening to the mechanical stops, but the indicated valve position was only about 70 percent. This was due to an error in electrical scaling of the position sensor. This scale factor error was present in the entire test series.

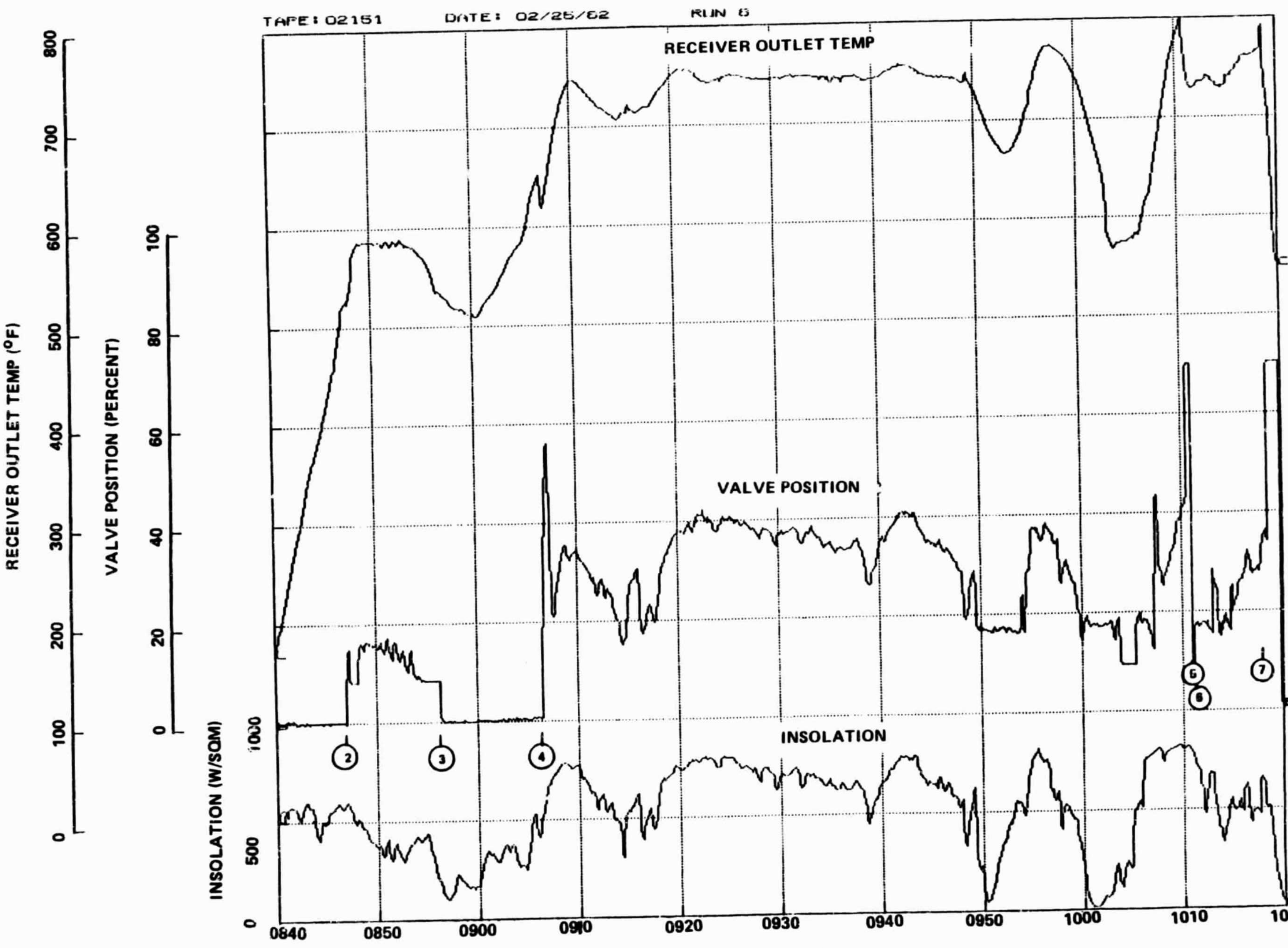

FIGURE A-4. SUMMARY PLOT FOR RUN 8 (TEST 4)

TABLE A-5. TEST EVENT SUMMARY: RUN 9 (TEST 5), FEBRUARY 25, 1982

Purpose: a. Evaluate transient response by use of sliding plate

b. Evaluate effect of varying control law constants

c. Evaluate effect of low fan speed

PRE-TEST NOTES:

- Receiver outlet temperature measurement changed to an alternate RTD.
- Counter was attached to the alternator voltage for calibration of the turbine speed sensor. Determined that previous runs had an actual turbine speed ~12% lower than indicated (Run 3 through Run 8).

EVENT LOG:

Event	Time	Description
1	12:39:44	Open sliding plate (not shown on plot)
2	12:42	Engine start
3	13:00	Adjust scale factor of turbine speed transducer
4	13:50	Low fan speed
5	14:11	High fan speed
6	14:30	Close door for 30 seconds(TAUISC X 2)
7	14:40	Close door for 30 seconds (TAUISC X 3.43)
8	14:50	Close door for 30 seconds
9	15:00	Close door for 1 minute (KIP = KIN X 2)
10	15:11	Close door for 1 minute
11	15:24:47	Close door; PCA OFF
12	15:27:15	Shutdown

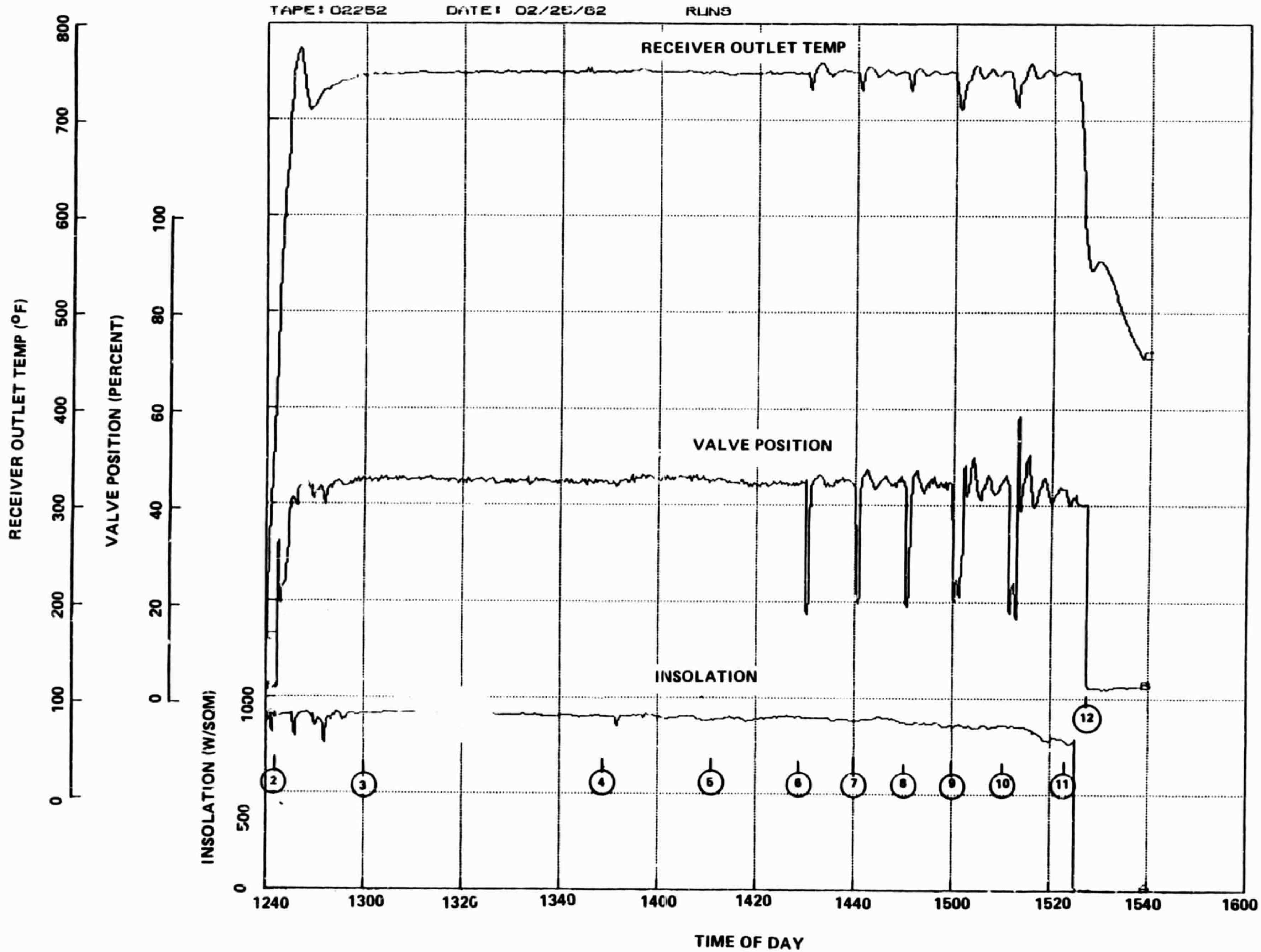

FIGURE A-5. SUMMARY PLOT FOR RUN 9 (TEST 5)

TABLE A-6. TEST EVENT SUMMARY: RUN 11 (TEST 6), FEBRUARY 26, 1982

Purpose: Continue evaluation of control constants

PRE-TEST NOTES:

- No modifications since last run.
- Prior to the start, the outer loop time constant, TAUISC, was set to twice its nominal value.

EVENT LOG:

Event	Time	Description
1	10:46:23	Open door (i.e., sliding plate)
2	10:50:29	Engine start (KIP = KIN X 4; TAUISC X 1)
3	12:14	Close door for 1 minute
4	12:37	KIP = KIN X 2; TAUISC X 2
5	13:49	Close door for 5 minutes (shutdown and restart). Try speed control mode at 40 krpm and 35 krpm
6	15:00	Close door and de-track

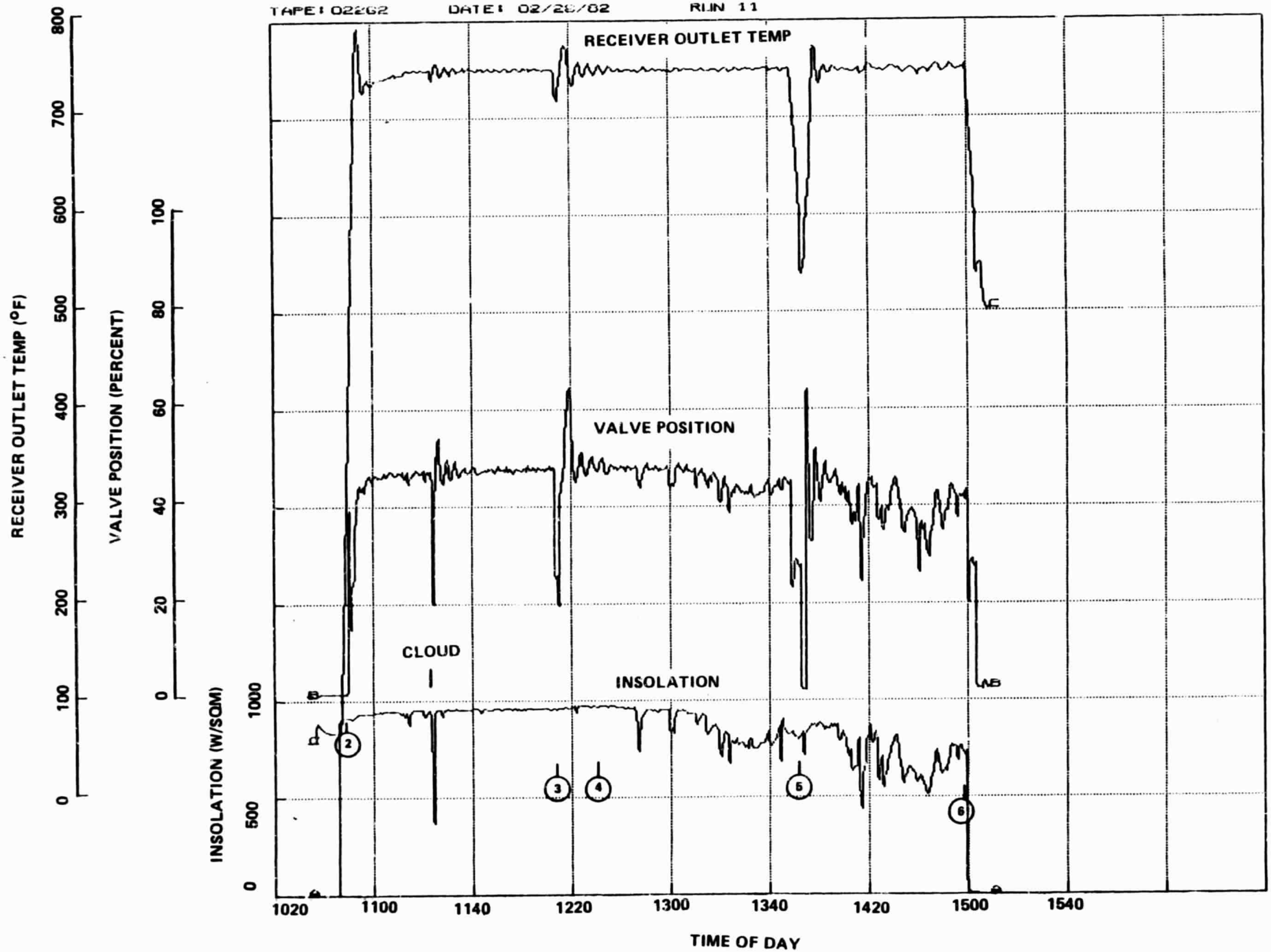

FIGURE A-6. SUMMARY PLOT FOR RUN 11 (TEST 6)

TABLE A-7. TEST EVENT SUMMARY: RUN 12 (TEST 7), MARCH 2, 1982

Purpose: Verify operation with cloud passages

PRE-TEST NOTES:

- Software changes implemented to initialize INT at 560°F (was 570°F) and go to hot restart if the turbine spins during pressure relief.

EVENT LOG:

Event	Time	Description
1	11:51	Open door
2	11:58	Engine start
3	12:36:15	Normal shutdown (low insolation)
4	12:37	Cloud gone -- door open to try restart. Vapor valve failed to respond to commands. Abort test.

POST-TEST NOTE:

- Filter problem apparent cause of inoperative valve.

SCSE:ApA:15

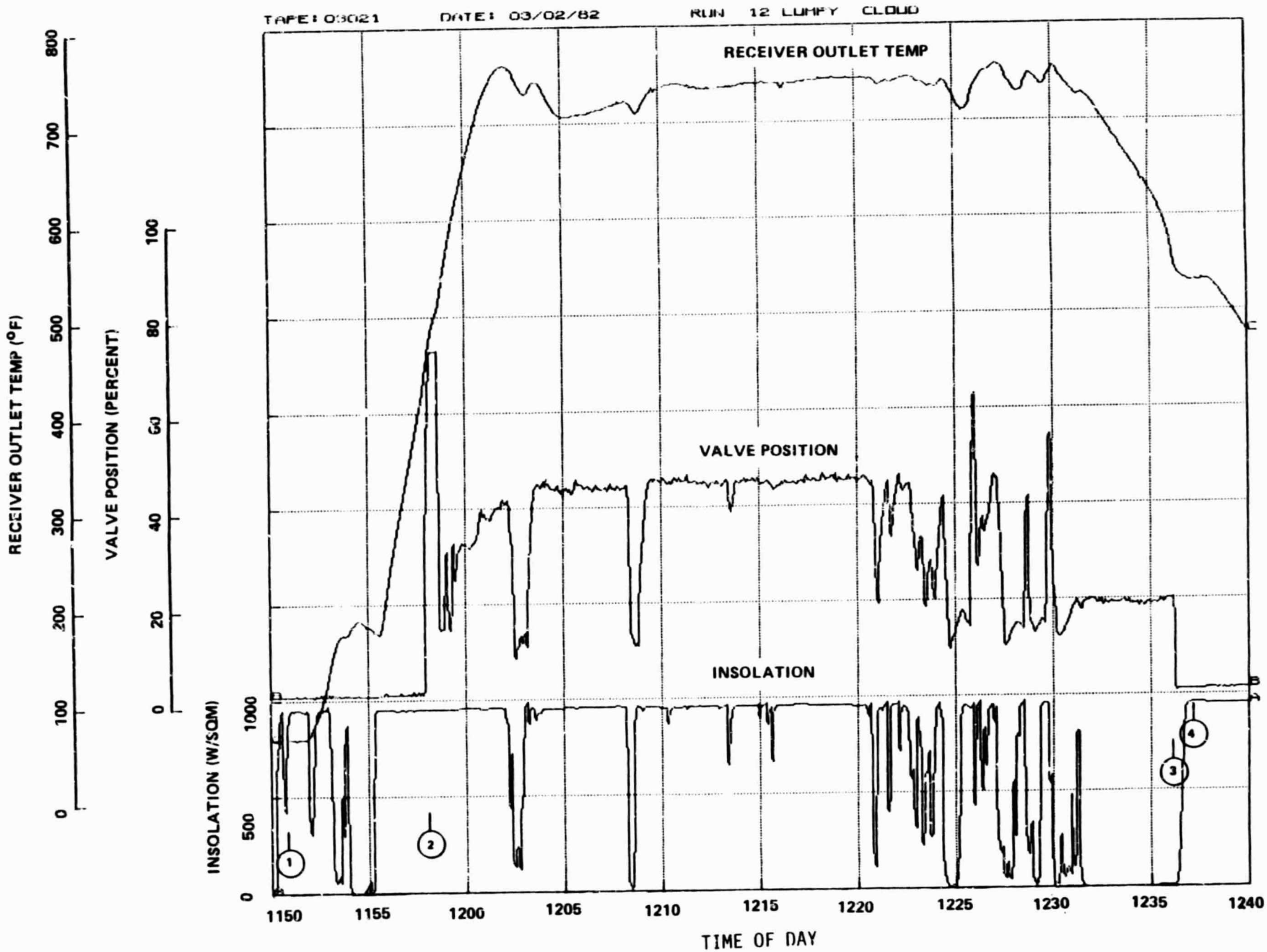

FIGURE A-7. SUMMARY PLOT FOR RUN 12 (TEST 7)

TABLE A-8. TEST EVENT SUMMARY: RUN 13 (TEST 8), MARCH 3, 1982

Purpose: Continue transient and steady-state response evaluation

PRE-TEST NOTES:

- Both start pump and valve filters cleaned as a result of Event 4 on Run 12.

EVENT LOG:

Event	Time	Description
1	08:30:16	Open door (sliding plate)
2	08:35:11	Engine start
3	09:44	Close door for 4.5 minutes
4	10:47	Close door for 5 minutes (shutdown and restart)
5	13:14	Close door for 2 minutes. Exercise speed control with inverter off while the door closed
6	13:23:30	Operator-initiated emergency shutdown; re-open door after 1 minute
7	14:13	Close door and allow Normal Shutdown (PCA OFF).
-	~14:20	Insert new EPROM set into RCIA with software modification to eliminate temperature overshoot observed in Event 3.
8	14:22	Open door
9	14:22:37	Engine start
10	14:41:00	Close door for 4.5 minutes. (Repeat of Event 3 to demonstrate the software modification.)
11	15:00:45	Low fan speed
12	15:18:45	High fan speed
13	15:30:00	Close door and allow Normal Shutdown (PCA OFF).

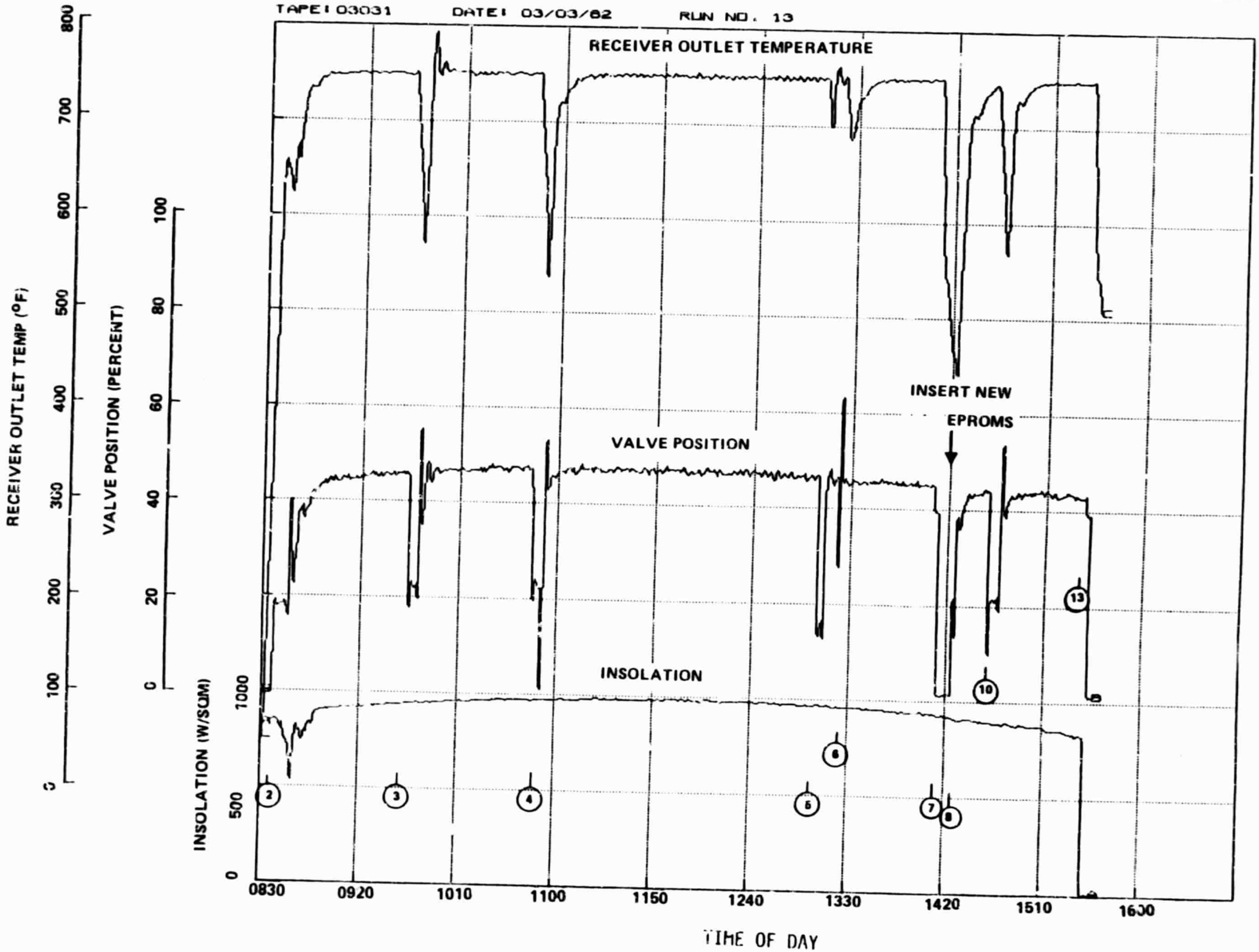

FIGURE A-8. SUMMARY PLOT FOR RUN 13 (TEST 8)

TABLE A-9. TEST EVENT SUMMARY: RUN 14 (TEST 9), MARCH 4, 1982

Purpose: Evaluate effect of turbine speed by varying inverter voltage

PRE-TEST NOTES:

- No system modifications.

EVENT LOG:

Event	Time	Description
1	13:05:52	Open door
2	13:10:00	Engine start
3	13:40:50	RCIA/MPC data link halt -- reset RCIA to recover and continue test
4	13:45:35	Open door
5	13:46:10	Engine start
6	14:13:45	Lower dc voltage from 500 V to 480 V
7	14:34:00	Increase dc voltage to 520 V
8	14:44	RCIA/MPC data link halt

POST-TEST NOTES:

- As the test concluded, the RCIA malfunctioned and the test was aborted.

C-2

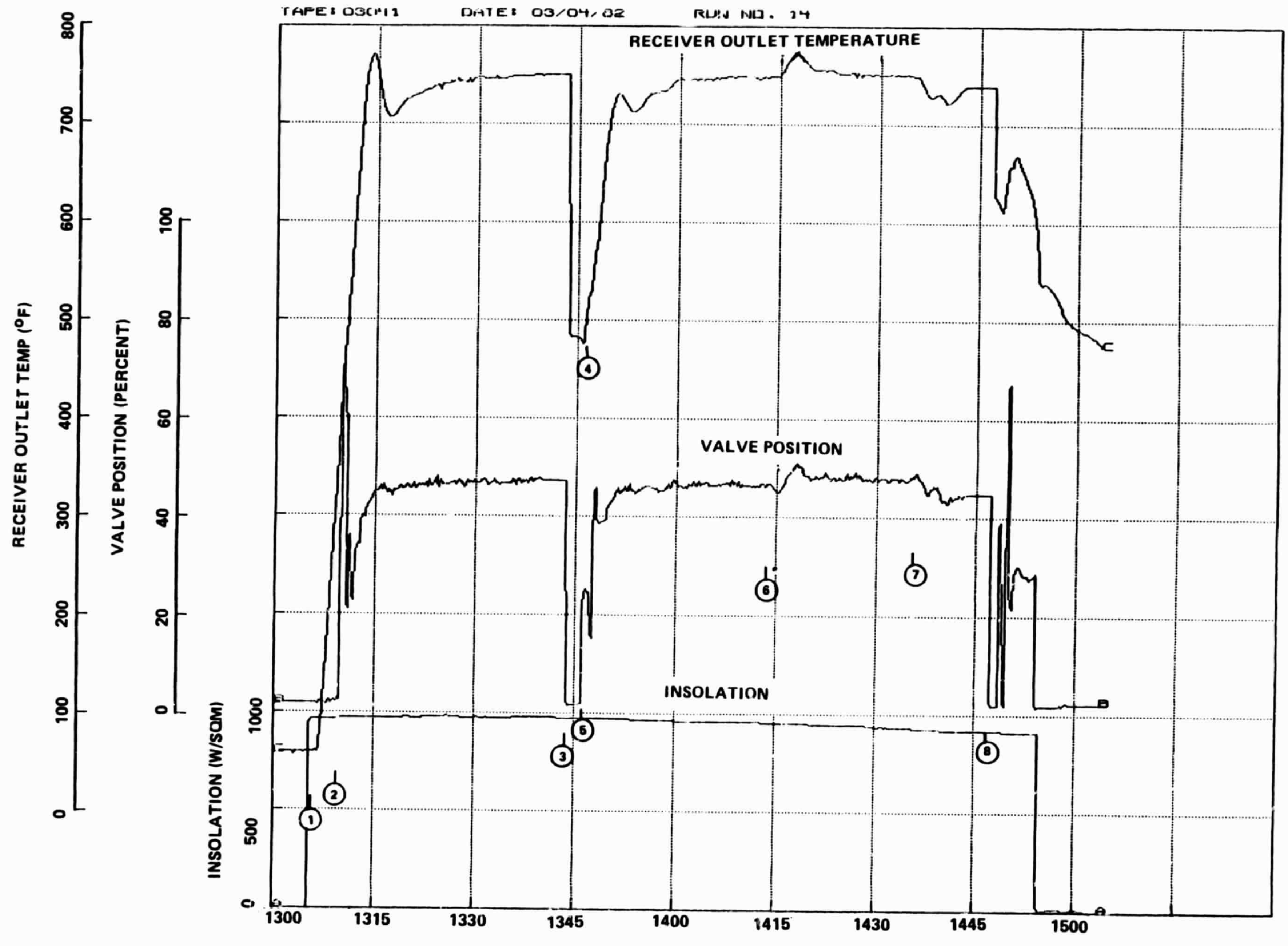

FIGURE A-9. SUMMARY PLOT FOR RUN 14 (TEST 9)

TABLE A-10. TEST EVENT SUMMARY: RUN 15 (TEST 10), MARCH 5, 1982

Purpose: Operate with low insolation -- perform multiple restarts

PRE-TEST NOTES:

- RCIA functioning normally; no changes made (see Run 16).

EVENT LOG:

Event	Time	Description
1	13:10:00	Open door
2	13:30:10	Engine start
-	various	The shutdown and restarts are the result of varying insolation
3	15:23:30	Close door and detrack

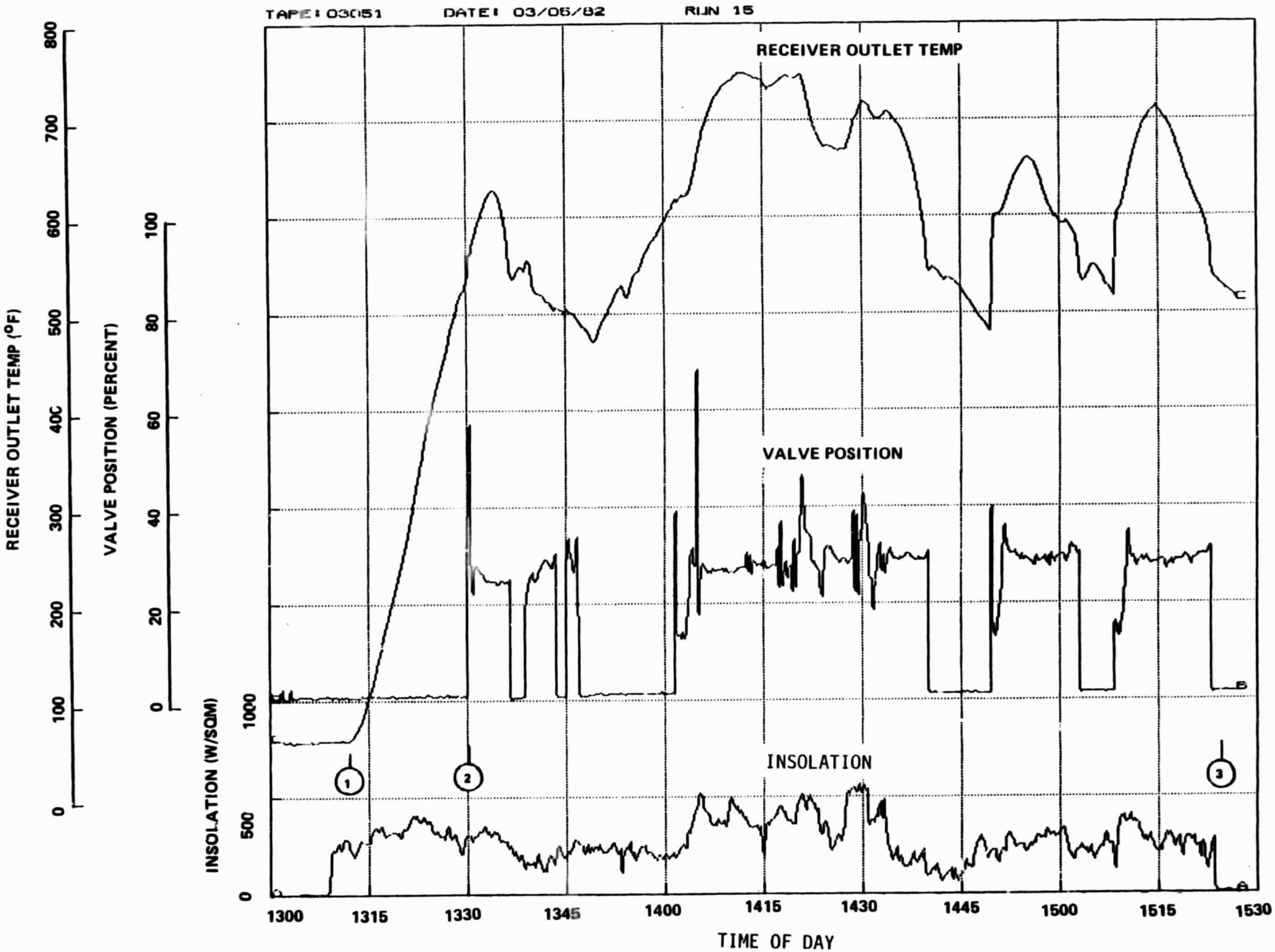

FIGURE A-10. SUMMARY PLOT FOR RUN 15 (TEST 10)

TABLE A-11. TEST EVENT SUMMARY: RUN 16 (TEST 11), MARCH 12, 1982

Purpose: Demonstrate smooth steady-state operation

PRE-TEST NOTES:

- RCIA problem encountered in Run 14 corrected by replacing the Z-80 chip.

EVENT LOG:

Event	Time	Description
1	13:50:20	Door open
2	13:55	Engine start
3	15:30:00	Close door; PCA OFF
4	15:32:40	Shutdown

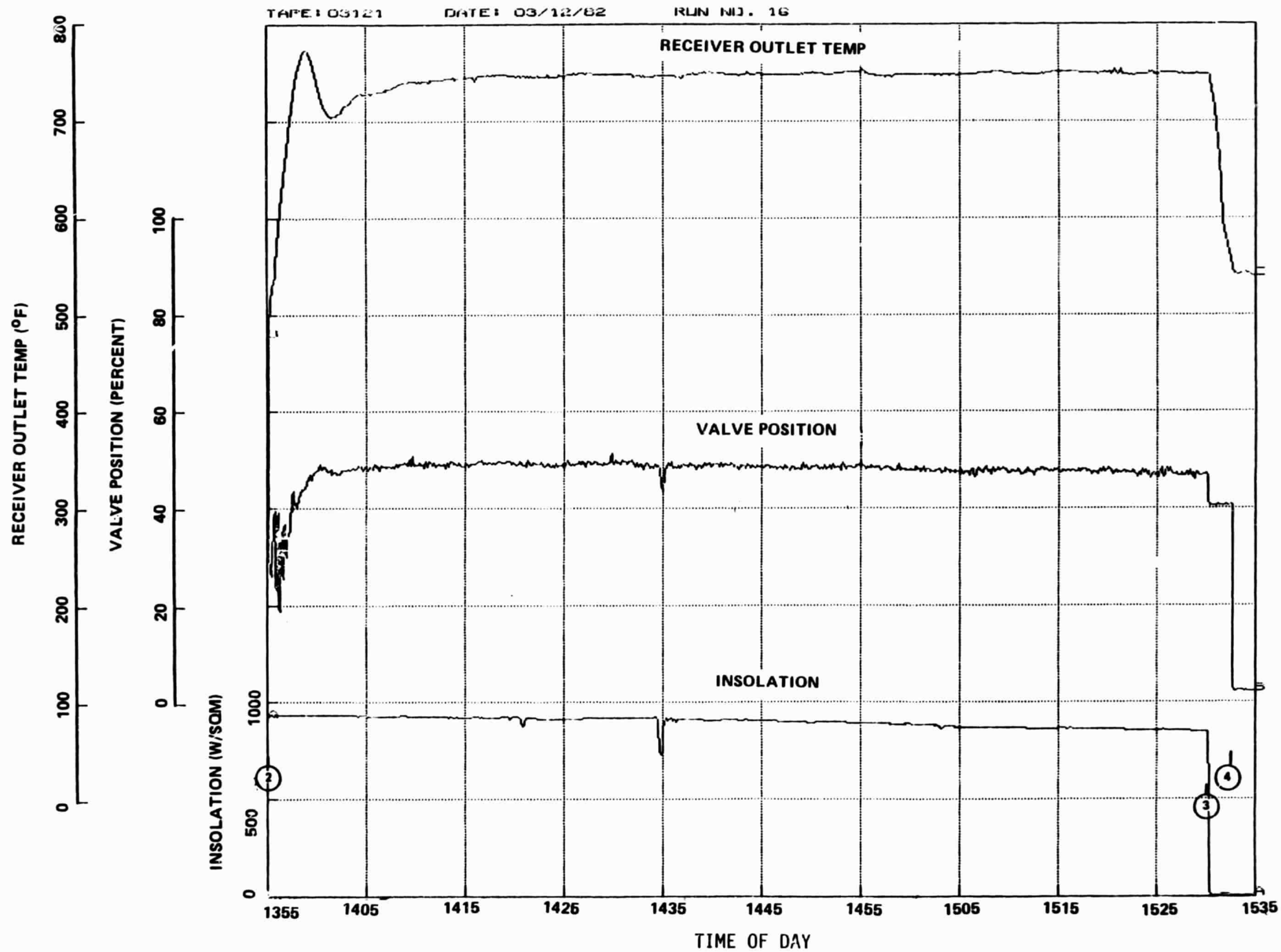

FIGURE A-11. SUMMARY PLOT FOR RUN 16 (TEST 11)

TABLE A-12. TEST EVENT SUMMARY: RUN 17 (TEST 12), MARCH 18, 1982

Purpose: Normal operation with scattered clouds

PRE-TEST NOTES:

- Work continuing to interface the inverter with the grid.

EVENT LOG:

Event	Time	Description
1	08:36:55	Door open
2	08:41:39	Engine start
3	09:43:32	Overspeed fault — allow normal shutdown

POST-TEST NOTES:

- After the test the dc breaker on the inverter was tripped, indicating an inverter problem.

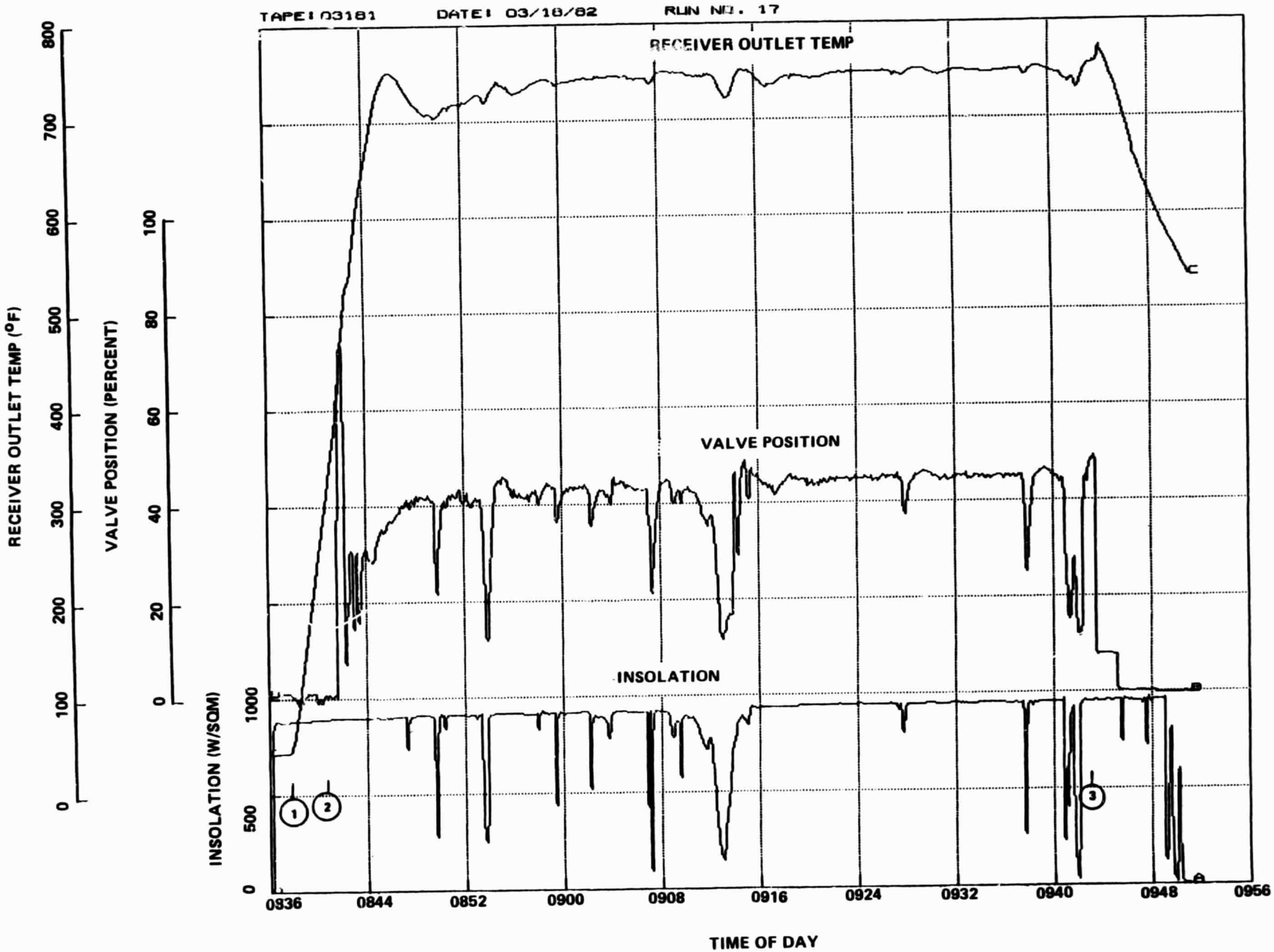

FIGURE A-12. SUMMARY PLOT FOR RUN 17 (TEST 12)

TABLE A-13. TEST EVENT SUMMARY: RUN 18 (TEST 13), MARCH 19, 1982

Purpose: Low power, steady state operation with high and low fan speed

PRE-TEST NOTES:

- 50% masking, "checkerboard" pattern.
- Start engine with by-pass valve closed.

EVENT LOG:

Event	Time	Description
1	10:55	Open door
2	11:04:05	Engine start
3	11:47:10	Low fan speed
4	12:32	High fan speed
5	12:53:40	Increase voltage from 495 Vdc to 550 Vdc
6	12:55	Anomalous speed transients attributed to inverter malfunction
7	13:37:40	Attempted to turn power supply on in parallel with alternator. Transients noted, tripped dc breaker on inverter. Abnormally high condenser pressures noted.

POST-TEST NOTES:

- Condenser pressure returned to normal after shutdown. High values during run attributed to heat imbalance caused by transients. Inoperative fan could have also caused condition, but no post-test evidence that fan was off during part of run.

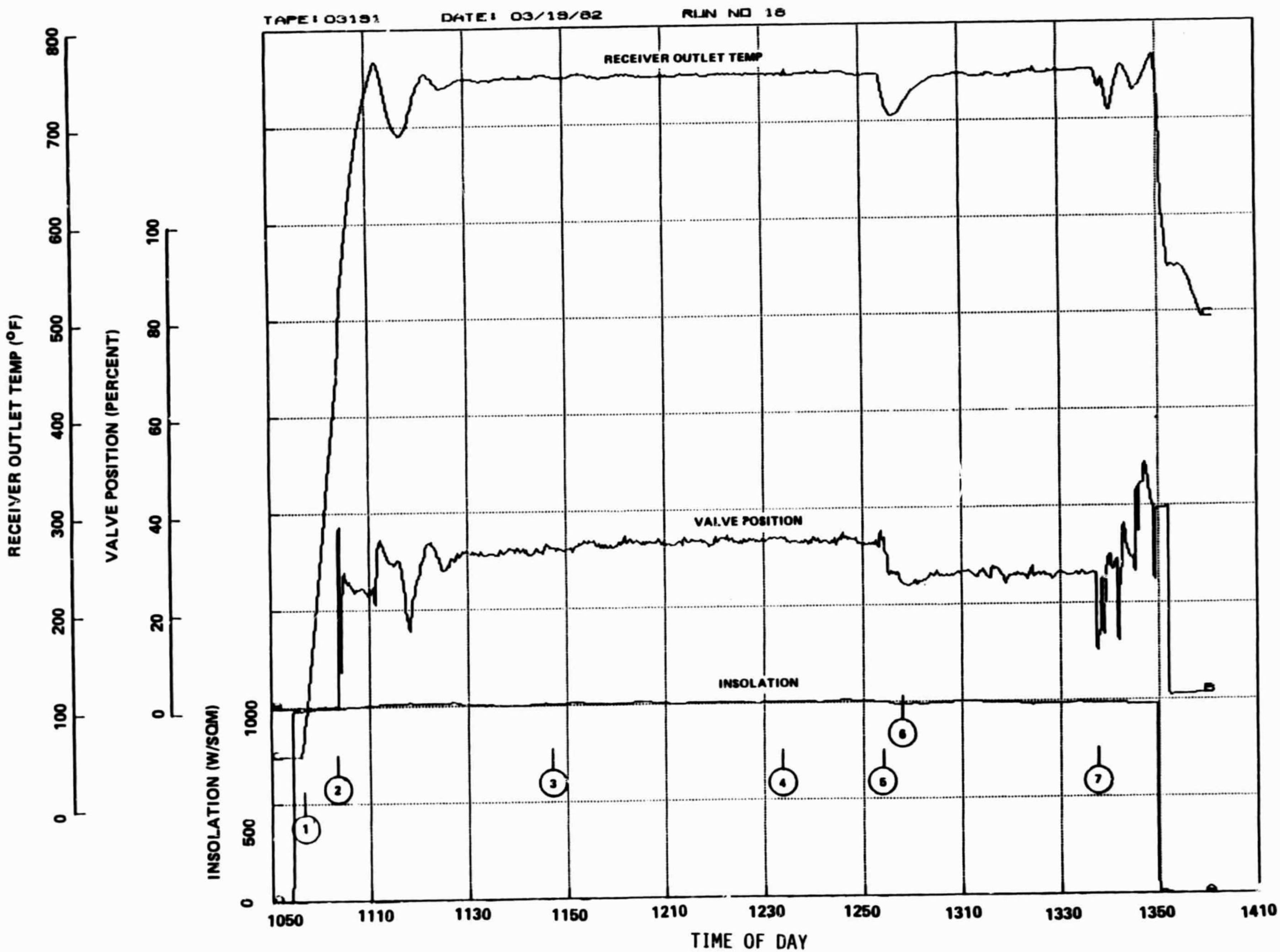

FIGURE A-13. SUMMARY PLOT FOR RUN 18 (TEST 13)

TABLE A-14. TEST EVENT SUMMARY: RUN 19 (TEST 14), MARCH 19, 1982

Purpose: Steady state operation at 75% power (25% masking)

NOTES:

- Start with by-pass valve closed.

EVENT LOG:

Event	Time	Description
1	15:04:40	Door open
2	15:07:41	Engine start
3	15:30:05	Door closed; PCA OFF
4	15:32:15	Normal shutdown

SCSE:ApA:15

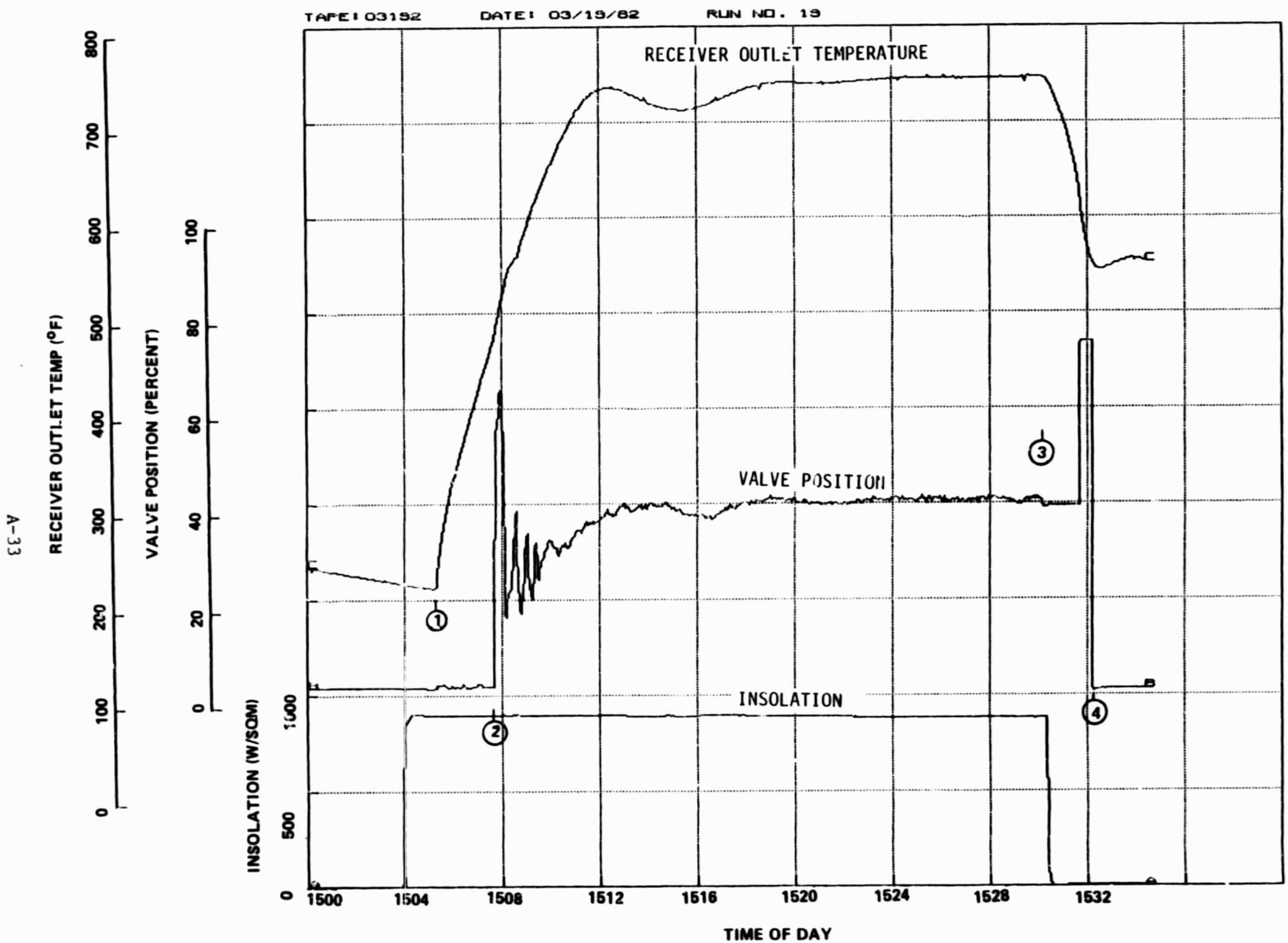

FIGURE A-14. SUMMARY PLOT FOR RUN 19 (TEST 14)

TABLE A-15. TEST EVENT SUMMARY: RUN 20 (TEST 15), MARCH 22, 1982

Purpose: Demonstrate steady state operation at 75% power (25% masking). Check operation with inverter power supply on in parallel with alternator.

NOTES:

- Start with by-pass valve closed.
- Bent lug on an inverter choke has been straightened -- this was the probable cause of inverter problems noted on Runs 17 and 18.

EVENT LOG:

Event	Time	Description
1	11:37:27	Door open
2	11:43:14	Engine start
3	12:32:25	Low fan speed
4	12:38	CNEXTP temp sensor failure -- heat dissipation mode and shutdown. By-pass the fault and continue test
5	12:42	Door open (not shown on plot)
6	12:43	Engine start
7	13:20	High fan speed (not shown on plot)
8	13:56:30	Fan off (not shown on plot)
9	14:03:30	Fan on (not shown on plot)
10	14.09:40	Fan off (not shown on plot)
11	14:12:20	Fan on (not shown on plot)
12	14:16	Increase voltage from 500 Vdc to 550 Vdc
13	14:21:40	Inverter power supply on
14	14:32:15	Inverter power supply off
15	14:40:50	Inverter power supply on
16	14:45:30	Door closed; high power mode
17	14:47:00	Shutdown

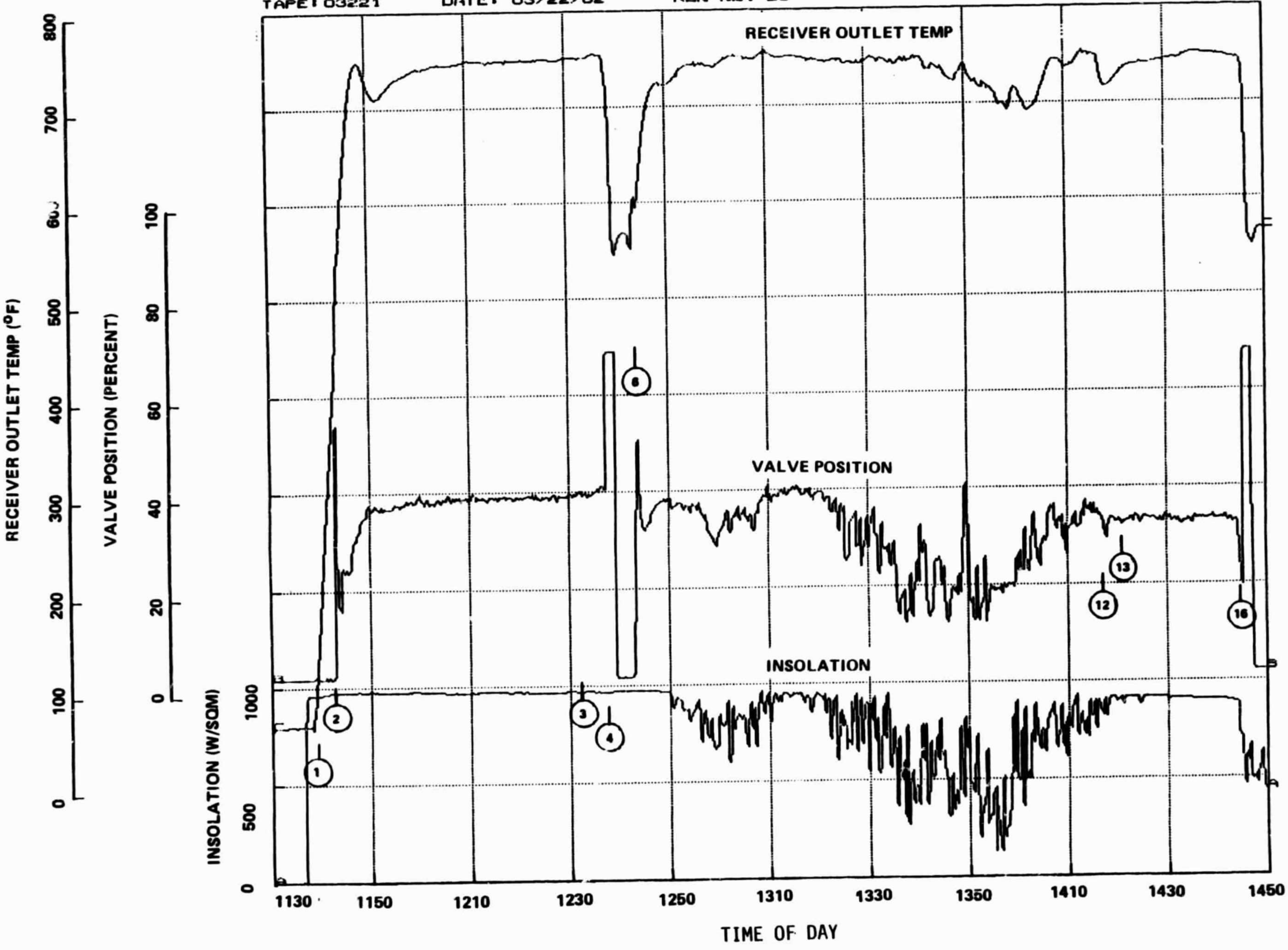

FIGURE A-15. SUMMARY PLOT FOR RUN 20 (TEST 15)

TABLE A-16. TEST EVENT SUMMARY: RUN 21 (TEST 16), MARCH 26, 1982

Purpose: Demonstrate power-to-grid mode

NOTES:

- Start with by-pass valve closed.
- Start with inverter power supply on and inverter connected to grid.

EVENT LOG:

Event	Time	Description
1	09:24:28	Door open
2	09:28	Engine start
3	09:37	Door closed for about 1 minute. Caused by temporary halt of serial data.
4	09:45:30	Turn off inverter power supply
5	09:57	Reduce voltage from 550 Vdc to 500 Vdc
6	10:01:49	Speed and voltage decreased due to cloud cover. The inverter apparently started malfunctioning, causing large oscillations in turbine speed, and a subsequent shutdown.
-	10:03	MPC computer malfunction

POST-TEST NOTES:

- After this test, the PCS was disassembled and the TAP returned to Barber-Nichols. Some inverter cards were returned to NOVA for repair.

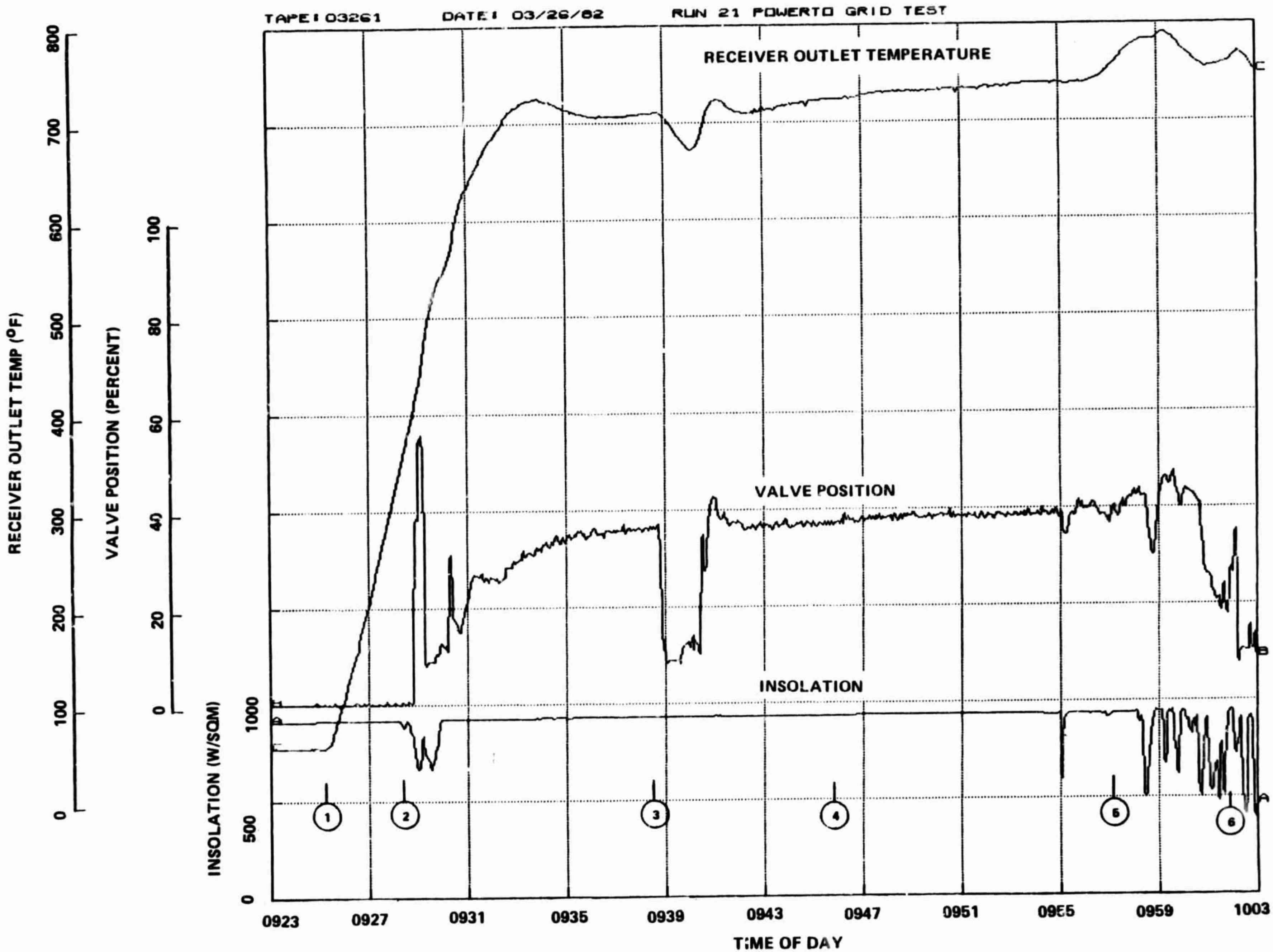

FIGURE A-16. SUMMARY PLOT FOR RUN 21 (TEST 16)

APPENDIX B

SAMPLE PRINTOUTS OF ALL DISPLAYS

<u>CONDITIONS:</u>

- Run No. 13 (Test No. 8)
- March 3, 1982
- Time Period of Printouts: 12:00:00 to 12:00:54
- Interval of Printout: 1 second

APPENDIX B

SAMPLE PRINTOUT OF ALL DISPLAYS

The following pages contain reduced copies of the complete printout record for a short (~1 minute) test period at noon for Run 13 (Test No. 8). This run was selected as being representative of a steady-state, normal operating condition.

Each printout is preceded by a page which contains a description of each heading. All printouts have the identical first three columns: time (self explanatory), RCIA data link status (RLS) and weather data link status (WLS). A value of zero for RLS and WLS is normal; a value of 1 would indicate a failure in the link.

The list of the printouts corresponds to that contained in Paragraph 3.4, i.e., display No. 1 is printed as Print 01. Since the number of columns on the printer is limited, each display is divided into two separate printed pages, e.g., Print 01 left (01L) and 01 right (01R). The display/print summary is given below.

Print No.	Display No.	Title	Table No.
01L and R	1	Power and Energy, Program OPWEG	B-1
02L and R	2	PCA Temps and Pressures	B-2
03L and R	3	Other PCA Measurements	B-3
04L and R	4	PCS Events (Discretes)	B-4
05L and R	5	ETS Data	B-5
06L and R	6	Weather Data	B-6
-	7	TBC Data (Not implemented)	-
08L and R	8	PCS Performance Data	B-7

PRINT 01 DESCRIPTION - POWER AND ENERGY

Print No.	Parameter	Description*
01L	PM1	Local Eppley pyrheliometer reading
01L	PT2**	PM1 corrected for circumsolar effects, i.e. flux available to concentrator
01L	E2	Energy available to concentrator
01L	PT3	Power available to receiver (theoretical)
01L	PT4	Power available to PCS (theoretical)
01L	PM4	Power available to PCS (measured value derived from mass flow and enthalpy rise)
01L	ET4	Efficiency of receiver (theoretical)
01L	EM4***	Efficiency of receiver (calculated)
01L	PT5	Power out of PCS (theoretical)
01L	PM5	Power out of PCS (measured)
01R	ET5	Efficiency of PCS (theoretical)
01R	EM5**	Efficiency of PCS (measured)
01R	PT6	Power out of inverter (theoretical)
01R	PM6	Power out of inverter (measured)
01R	E6	Energy out of inverter
01R	ET6	Efficiency of inverter (theoretical)
01R	EM6	Efficiency of inverter (measured)
01R	OEP**	Efficiency of module based on input and output power
01R	OEE**	Efficiency of module based on input and output energy

*See TR-SCSE-044A for an explanation of the equations used for the Power and Energy calculations (Ref. 23)

**The definition of these parameters has changed slightly in the latest version of program OPWEG (see TR-SCSE-044B). The 'A' version of the program was used for the tests reported here.

***The value of EM4 for Run 13 and all runs prior to 16 were low due to incorrect area for concentrator. Add 5.5% to value printed to obtain correct number, i.e. 89.9 becomes 95.4.

TABLE B-1. PRINTOUT OF 01 FOR RUN 13

FACC SMALL COMMUNITY SOLAR EXPERIMENT

PRINT: 01L DATE: 03/03/82 PAGE: 0001

TIME	RLS	WLS	PM1 W/M*M	PT2 W/M*M	E2 KWH	PT3 KW	PT4 KW	PM4 KW	ET4 PERCENT	EM4* PERCENT	PT5 KW	PM5 KW
12:00:00	0	0	0982.8	0948.4	0280.6	0078.7	0076.8	0070.8	0097.5	0089.9	0016.4	0016.2
12:00:01	0	0	0982.9	0948.1	0280.7	0078.7	0076.8	0072.2	0097.5	0091.7	0016.8	0016.3
12:00:02	0	0	0982.8	0948.4	0280.7	0078.7	0076.8	0071.2	0097.5	0090.4	0016.5	0016.4
12:00:03	0	0	0982.8	0948.4	0280.7	0078.7	0076.8	0071.1	0097.5	0090.2	0016.5	0016.1
12:00:04	0	0	0982.8	0948.4	0280.7	0078.7	0076.8	0071.0	0097.5	0090.2	0016.4	0016.1
12:00:05	0	0	0982.5	0948.1	0280.8	0078.7	0076.8	0071.8	0097.5	0091.1	0016.7	0016.0
12:00:06	0	0	0982.5	0948.1	0280.8	0078.7	0076.8	0071.1	0097.5	0090.3	0016.5	0016.1
12:00:07	0	0	0982.8	0948.4	0280.8	0078.7	0076.8	0071.2	0097.5	0090.4	0016.5	0016.2
12:00:08	0	0	0983.4	0948.9	0280.8	0078.8	0076.9	0071.2	0097.5	0090.4	0016.5	0016.2
12:00:09	0	0	0983.1	0948.6	0280.9	0078.8	0076.9	0071.2	0097.5	0090.3	0016.5	0016.3
12:00:10	0	0	0983.4	0948.9	0280.9	0078.8	0076.9	0071.8	0097.5	0091.1	0016.7	0016.2
12:00:11	0	0	0982.8	0948.4	0280.9	0078.7	0076.8	0071.2	0097.5	0090.3	0016.9	0016.2
12:00:12	0	0	0982.8	0948.4	0280.9	0078.7	0076.8	0072.3	0097.5	0091.8	0016.8	0016.3
12:00:13	0	0	0982.5	0948.1	0281.0	0078.7	0076.8	0071.3	0097.5	0090.5	0016.5	0016.2
12:00:14	0	0	0983.1	0948.6	0281.0	0078.8	0076.9	0071.1	0097.5	0090.2	0016.4	0016.1
12:00:15	0	0	0982.5	0948.1	0281.0	0078.7	0076.8	0071.1	0097.5	0090.3	0016.5	0016.0
12:00:16	0	0	0982.8	0948.4	0281.0	0078.7	0076.8	0071.0	0097.5	0090.1	0016.4	0016.2
12:00:17	0	0	0982.8	0948.4	0281.1	0078.7	0076.8	0071.8	0097.5	0091.1	0016.7	0016.1
12:00:18	0	0	0983.1	0948.6	0281.1	0078.8	0076.9	0071.2	0097.5	0090.3	0016.5	0016.0
12:00:19	0	0	0982.8	0948.4	0281.1	0078.7	0076.8	0071.1	0097.5	0090.3	0016.5	0016.0
12:00:20	0	0	0982.8	0948.4	0281.1	0078.7	0076.8	0069.7	0097.5	0088.5	0016.0	0016.4
12:00:21	0	0	0982.8	0948.4	0281.2	0078.7	0076.8	0071.9	0097.5	0091.3	0016.7	0016.1
12:00:22	0	0	0983.1	0948.6	0281.2	0078.8	0076.9	0071.2	0097.5	0090.4	0016.5	0016.4
12:00:23	0	0	0982.8	0948.4	0281.2	0078.7	0076.8	0071.8	0097.5	0091.2	0016.7	0016.3
12:00:24	0	0	0983.1	0948.6	0281.2	0078.8	0076.9	0070.9	0097.5	0089.9	0016.4	0016.1
12:00:25	0	0	0983.1	0948.6	0281.3	0078.8	0076.9	0072.1	0097.5	0091.5	0016.8	0016.1
12:00:26	0	0	0983.4	0948.9	0281.3	0078.8	0076.9	0071.3	0097.5	0090.4	0016.5	0016.3
12:00:27	0	0	0983.7	0949.2	0281.3	0078.8	0076.9	0070.4	0097.5	0089.3	0016.2	0016.3
12:00:28	0	0	0983.7	0949.2	0281.3	0078.8	0076.9	0071.3	0097.5	0090.5	0016.5	0016.2
12:00:29	0	0	0983.4	0948.9	0281.3	0078.8	0076.9	0071.0	0097.5	0090.1	0016.4	0016.4
12:00:30	0	0	0983.7	0949.2	0281.4	0078.8	0076.9	0070.6	0097.5	0089.6	0016.3	0016.2
12:00:31	0	0	0984.0	0949.5	0281.4	0078.8	0076.9	0071.2	0097.5	0090.3	0016.5	0016.2
12:00:32	0	0	0984.0	0949.5	0281.4	0078.8	0076.9	0071.4	0097.5	0090.5	0016.5	0016.1
12:00:33	0	0	0983.7	0949.2	0281.4	0078.8	0076.9	0070.9	0097.5	0089.9	0016.4	0016.1
12:00:34	0	0	0983.7	0949.2	0281.5	0078.8	0076.9	0071.1	0097.5	0090.1	0016.4	0016.2
12:00:35	0	0	0983.7	0949.2	0281.5	0078.8	0076.9	0071.2	0097.5	0090.2	0016.5	0016.4
12:00:36	0	0	0983.7	0949.2	0281.5	0078.8	0076.9	0072.5	0097.5	0091.9	0016.9	0016.0
12:00:37	0	0	0985.2	0950.7	0281.5	0078.9	0077.0	0071.9	0097.5	0091.1	0016.7	0016.1
12:00:38	0	0	0984.9	0950.4	0281.6	0078.9	0077.0	0071.4	0097.5	0090.4	0016.5	0016.5
12:00:39	0	0	0984.6	0950.1	0281.6	0078.9	0077.0	0071.1	0097.5	0090.1	0016.4	0016.8
12:00:40	0	0	0984.9	0950.4	0281.6	0078.9	0077.0	0072.5	0097.5	0091.9	0016.9	0016.1
12:00:41	0	0	0984.9	0950.4	0281.6	0078.9	0077.0	0072.6	0097.5	0092.C	0016.9	0016.3
12:00:42	0	0	0984.9	0950.4	0281.7	0078.9	0077.0	0071.4	0097.5	0090.4	0016.5	0016.7
12:00:43	0	0	0984.3	0949.8	0281.7	0078.9	0077.0	0071.3	0097.5	0090.4	0016.5	0016.2
12:00:44	0	0	0984.6	0950.1	0281.7	0078.9	0077.0	0071.9	0097.5	0091.1	0016.7	0015.9
12:00:45	0	0	0984.9	0950.4	0281.7	0078.9	0077.0	0071.0	0097.5	0089.9	0016.4	0016.7
12:00:46	0	0	0985.4	0950.9	0281.8	0079.0	0077.0	0070.3	0097.5	0089.0	0016.2	0016.4
12:00:47	0	0	0985.7	0951.2	0281.8	0079.0	0077.1	0071.5	0097.5	0090.5	0016.6	0016.0
12:00:48	0	0	0985.4	0950.9	0281.8	0079.0	0077.0	0071.6	0097.5	0090.6	0016.6	0017.0
12:00:49	0	0	0985.4	0950.9	0281.8	0079.0	0077.0	0071.2	0097.5	0090.2	0016.5	0016.3
12:00:50	0	0	0985.2	0950.7	0281.9	0078.9	0077.0	0072.4	0097.5	0091.7	0016.9	0016.0
12:00:51	0	0	0985.2	0950.7	0281.9	0078.9	0077.0	0071.3	0097.5	0090.3	0016.5	0013.7
12:00:52	0	0	0985.4	0950.9	0281.9	0079.0	0077.0	0070.9	0097.5	0089.7	0016.4	0016.0
12:00:53	0	0	0985.7	0951.2	0281.9	0079.0	0077.1	0070.4	0097.5	0089.1	0016.2	0016.0
12:00:54	0	0	0986.0	0951.4	0282.0	0079.0	0077.1	0070.4	0097.5	0089.0	0016.2	0016.1

*Values incorrect, see note on previous page

TABLE B-1. PRINTOUT OF 01 FOR RUN 13 (Continued)

FACC SMALL COMMUNITY SOLAR EXPERIMENT
DATE: 03/03/82

PRINT: 01R

TIME	RLS	WLS	ET5 PERCENT	EM5 PERCENT	PT6 KW	PM6 KW	E6 KWH	ET6 PERCENT	EM6 PERCENT	DEP PERCENT	DEE PERCENT
12:00:00	0	0	0023.0	0022.9	0013.6	0013.5	0036.8	0083.5	0083.1	0015.4	0013.1
12:00:01	0	0	0023.2	0022.5	0013.6	0013.5	0036.8	0083.6	0083.0	0015.4	0013.1
12:00:02	0	0	0023.0	0023.1	0013.8	0013.6	0036.8	0083.8	0082.5	0015.5	0013.1
12:00:03	0	0	0023.0	0022.7	0013.4	0013.6	0036.8	0083.3	0084.0	0015.5	0013.1
12:00:04	0	0	0023.0	0022.7	0013.4	0013.5	0036.8	0083.3	0083.8	0015.4	0013.1
12:00:05	0	0	0023.1	0022.3	0013.3	0013.4	0036.8	0083.2	0083.9	0015.4	0013.1
12:00:06	0	0	0023.0	0022.7	0013.5	0013.5	0036.8	0083.4	0083.8	0015.4	0013.1
12:00:07	0	0	0023.0	0022.8	0013.5	0013.5	0036.8	0083.5	0083.1	0015.4	0013.1
12:00:08	0	0	0023.0	0022.7	0013.5	0013.5	0036.8	0083.4	0083.4	0015.4	0013.1
12:00:09	0	0	0023.0	0022.9	0013.6	0013.8	0036.8	0083.6	0084.5	0015.7	0013.1
12:00:10	0	0	0023.1	0022.5	0013.5	0013.4	0036.8	0083.4	0083.2	0015.3	0013.1
12:00:11	0	0	0023.0	0022.7	0013.5	0013.5	0036.8	0083.4	0083.6	0015.4	0013.1
12:00:12	0	0	0023.2	0022.5	0013.6	0013.5	0036.8	0083.6	0083.0	0015.4	0013.1
12:00:13	0	0	0023.1	0022.7	0013.5	0013.5	0036.8	0083.4	0083.7	0015.4	0013.1
12:00:14	0	0	0023.0	0022.7	0013.4	0013.4	0036.8	0083.3	0083.4	0015.3	0013.1
12:00:15	0	0	0023.0	0022.5	0013.3	0013.4	0036.8	0083.1	0084.1	0015.4	0013.1
12:00:16	0	0	0023.0	0022.8	0013.5	0013.6	0036.8	0083.4	0083.9	0015.5	0013.1
12:00:17	0	0	0023.1	0022.5	0013.4	0013.4	0036.8	0083.3	0083.3	0015.4	0013.1
12:00:18	0	0	0023.0	0022.4	0013.3	0013.3	0036.8	0083.1	0083.6	0015.2	0013.1
12:00:19	0	0	0023.0	0022.5	0013.3	0013.4	0036.8	0083.2	0083.9	0015.4	0013.1
12:00:20	0	0	0022.9	0023.5	0013.7	0013.7	0036.8	0083.8	0083.7	0015.7	0013.1
12:00:21	0	0	0023.1	0022.4	0013.4	0013.5	0036.8	0083.3	0083.7	0015.4	0013.1
12:00:22	0	0	0023.0	0023.1	0013.8	0013.7	0036.8	0083.8	0083.6	0015.7	0013.1
12:00:23	0	0	0023.1	0022.7	0013.6	0013.4	0036.8	0083.6	0082.6	0015.4	0013.1
12:00:24	0	0	0023.0	0022.8	0013.4	0013.4	0036.8	0083.3	0083.2	0015.3	0013.1
12:00:25	0	0	0023.1	0022.4	0013.4	0013.5	0036.8	0083.3	0083.6	0015.4	0013.1
12:00:26	0	0	0023.0	0022.8	0013.6	0013.5	0036.8	0083.6	0083.1	0015.4	0013.1
12:00:27	0	0	0023.0	0023.2	0013.6	0013.6	0036.9	0083.6	0083.1	0015.5	0013.1
12:00:28	0	0	0023.1	0022.7	0013.5	0013.5	0036.9	0083.5	0083.2	0015.4	0013.1
12:00:29	0	0	0023.0	0023.0	0013.7	0013.5	0036.9	0083.7	0082.4	0015.4	0013.1
12:00:30	0	0	0023.0	0022.9	0013.5	0013.4	0036.9	0083.4	0083.1	0015.3	0013.1
12:00.31	0	0	0023.0	0022.8	0013.5	0013.4	0036.9	0083.5	0082.7	0015.3	0013.1
12:00:32	0	0	0023.1	0022.5	0013.4	0013.6	0036.9	0083.3	0084.3	0015.5	0013.1
12:00:33	0	0	0023.0	0022.8	0013.5	0013.6	0036.9	0083.4	0084.2	0015.5	0013.1
12:00:34	0	0	0023.0	0022.9	0013.6	0013.4	0036.9	0083.5	0082.8	0015.3	0013.1
12:00:35	0	0	0023.0	0023.0	0013.7	0013.7	0036.9	0083.7	0083.4	0015.6	0013.1
12:00:36	0	0	0023.2	0022.1	0013.3	0013.5	0036.9	0083.1	0084.3	0015.4	0013.1
12:00:37	0	0	0023.1	0022.5	0013.5	0013.5	0036.9	0083.4	0083.5	0015.4	0013.1
12:00:38	0	0	0023.1	0023.1	0013.8	0013.6	0036.9	0083.8	0082.6	0015.5	0013.1
12:00:39	0	0	0023.0	0023.6	0014.2	0013.9	0036.9	0084.3	0082.5	0015.8	0013.1
12:00:40	0	0	0023.2	0022.2	0013.4	0013.5	0036.9	0083.3	0084.1	0015.4	0013.1
12:00:41	0	0	0023.2	0022.4	0013.6	0013.7	0036.9	0083.5	0084.1	0015.6	0013.1
12:00:42	0	0	0023.1	0023.5	0014.1	0014.0	0036.9	0084.2	0083.5	0015.9	0013.1
12:00:43	0	0	0023.1	0022.7	0013.5	0013.5	0036.9	0083.5	0083.4	0015.1	0013.1
12:00:44	0	0	0023.1	0022.1	0013.2	0013.2	0036.9	0083.0	0082.7	0015.0	0013.1
12:00:45	0	0	0023.0	0023.6	0014.1	0013.9	0036.9	0084.2	0082.8	0015.8	0013.1
12:00:46	0	0	0022.9	0023.4	0013.8	0013.6	0036.9	0083.8	0083.0	0015.5	0013.1
12:00:47	0	0	0023.1	0022.4	0013.4	0013.5	0036.9	0083.2	0084.0	0015.3	0013.1
12:00:48	0	0	0023.1	0023.8	0014.4	0014.3	0036.9	0084.6	0083.7	0016.3	0013.1
12:00:49	0	0	0023.0	0022.8	0013.6	0013.4	0036.9	0083.5	0082.4	0015.3	0013.1
12:00:50	0	0	0023.2	0022.2	0013.4	0013.4	0036.9	0083.2	0083.8	0015.3	0013.1
12:00:51	0	0	0023.0	0022.1	0013.0	0013.3	0036.9	0082.7	0084.3	0015.1	0013.1
12:00:52	0	0	0023.0	0022.7	0013.4	0013.5	0036.9	0083.2	0084.0	0015.4	0013.1
12:00:53	0	0	0022.9	0022.8	0013.4	0013.4	0037.0	0083.2	0083.8	0015.3	0013.1

PRINT 02 DESCRIPTION - PCA TEMPERATURES AND PRESSURES

Print No.	Parameter	Description
02L	RCSTP1	Receiver shell temperature at location 1*
02L	RCSTP2	Receiver shell temperature at location 2*
02L	RCSTP3	Receiver shell temperature at location 3*
02L	RCSTP4	Receiver shell temperature at location 4*
02L	RCSTP5	Receiver shell temperature at location 5*
02L	RCSTP6	Receiver shell temperature at location 6*
02L	RCOTTP	Receiver fluid outlet temperature
02L	TRINTP	Turbine inlet temperature
02L	TREXTP	Turbine exit temperature
02L	CNINTP	Condenser inlet temperature
02R	CNEXTP	Condenser exit temperature
02R	RLINTP	Regenerator liquid inlet temperature
02R	RLEXTP	Regenerator liquid exit temperature
02R	ALTTP**	Alternator temperature
02R	RCOTPR	Receiver outlet pressure
02R	TRINPR	Turbine inlet pressure
02R	TREXPR	Turbine exit pressure
02R	CNEXPR	Condenser exit pressure
02R	SYINPR	System (feed) pump inlet pressure
02R	SYOTPR	System (feed) pump exit pressure

*Locations of these thermocouples are defined in Figure 4-5.

**This thermocouple was inoperative for these tests

TABLE B-2. PRINTOUT OF 02 FOR RUN 13

FACC SMALL COMMUNITY SOLAR EXPERIMENT

PRINT: 02L   DATE: 03/03/82   PAGE: 0001

TIME	RLS	WLS	RCSTP1 DEG F	RCSTP2 DEG F	RCSTP3 DEG F	RCSTP4 DEG F	RCSTP5 DEG F	RCSTP6 DEG F	RCOTTP DEG F	TRINTP DEG F	TREXTP DEG F	CNINTP DEG F
12:00:00	0	0	0789.0	0775.4	0679.8	0606.2	0589.0	0394.2	0750.4	0745.2	0517.6	0172.9
12:00:01	0	0	0788.6	0778.2	0679.8	0606.6	0589.0	0394.2	0750.0	0741.6	0517.6	0172.6
12:00:02	0	0	0789.0	0776.2	0679.8	0607.0	0589.0	0394.2	0750.4	0741.6	0517.6	0173.0
12:00:03	0	0	0789.0	0777.8	0679.8	0607.8	0589.0	0394.2	0750.4	0743.6	0517.6	0173.0
12:00:04	0	0	0788.6	0775.4	0679.8	0606.2	0589.0	0393.8	0750.4	0744.0	0517.6	0173.0
12:00:05	0	0	0788.6	0776.2	0679.8	0605.4	0589.0	0394.2	0750.4	0741.6	0517.6	0173.0
12:00:06	0	0	0789.4	0776.2	0679.4	0607.0	0589.4	0394.2	0750.4	0743.6	0517.6	0173.2
12:00:07	0	0	0789.0	0776.2	0679.8	0607.0	0589.0	0394.2	0749.6	0743.6	0517.6	0173.2
12:00:08	0	0	0788.6	0777.8	0679.8	0608.2	0589.0	0394.2	0750.8	0743.6	0517.6	0173.2
12:00:09	0	0	0789.0	0777.8	0679.8	0607.0	0589.0	0394.2	0749.6	0743.6	0518.0	0173.0
12:00:10	0	0	0788.6	0777.8	0679.8	0606.2	0589.0	0394.2	0750.4	0743.6	0518.0	0173.5
12:00:11	0	0	0788.6	0777.8	0679.6	0606.6	0588.2	0394.2	0748.0	0743.6	0517.6	0173.0
12:00:12	0	0	0789.0	0776.2	0679.8	0606.2	0589.0	0393.4	0750.0	0744.0	0518.0	0173.1
12:00:13	0	0	0788.6	0777.8	0679.0	0606.2	0589.0	0393.8	0750.4	0744.0	0518.0	0173.2
12:00:14	0	0	0789.0	0777.8	0679.8	0606.2	0589.0	0394.2	0750.4	0745.2	0517.6	0173.2
12:00:15	0	0	0789.8	0777.8	0679.8	0606.2	0589.0	0394.2	0750.4	0743.6	0517.6	0173.4
12:00:16	0	0	0788.6	0777.8	0679.8	0606.2	0589.0	0394.6	0750.4	0743.6	0517.2	0173.4
12:00:17	0	0	0788.6	0777.8	0679.8	0606.6	0589.0	0394.2	0750.4	0743.6	0517.6	0173.3
12:00:18	0	0	0789.0	0776.2	0679.6	0606.2	0589.0	0393.8	0750.4	0743.6	0518.0	0173.2
12:00:19	0	0	0789.0	0775.8	0679.8	0606.2	0589.0	0395.4	0750.4	0743.6	0517.6	0173.3
12:00:20	0	0	0789.4	0777.8	0679.6	0606.2	0589.8	0394.2	0750.8	0743.6	0517.6	0173.5
12:00:21	0	0	0789.4	0777.8	0680.2	0606.2	0589.0	0393.8	0750.4	0743.6	0519.6	0173.4
12:00:22	0	0	0788.2	0777.8	0679.8	0606.6	0589.0	0394.2	0750.4	0741.6	0518.0	0173.5
12:00:23	0	0	0788.6	0775.8	0679.8	0607.0	0589.0	0394.2	0750.0	0743.6	0517.6	0173.6
12:00:24	0	0	0787.0	0776.2	0679.4	0607.0	0589.0	0394.2	0749.6	0743.6	0518.0	0173.7
12:00:25	0	0	0788.6	0777.8	0679.8	0606.6	0589.0	0394.2	0750.4	0741.6	0518.0	0173.9
12:00:26	0	0	0789.0	0776.6	0679.0	0606.6	0589.0	0394.2	0750.4	0741.6	0518.4	0174.2
12:00:27	0	0	0789.0	0775.8	0679.4	0606.2	0589.0	0394.2	0750.4	0744.0	0517.6	0173.8
12:00:28	0	0	0788.6	0779.4	0679.8	0606.2	0589.0	0393.8	0750.0	0743.6	0518.0	0174.0
12:00:29	0	0	0789.0	0776.6	0679.4	0606.2	0589.0	0394.2	0749.6	0743.6	0517.6	0173.8
12:00:30	0	0	0787.8	0775.8	0679.4	0606.2	0589.0	0394.2	0750.0	0740.8	0518.0	0173.6
12:00:31	0	0	0789.0	0776.2	0677.4	0607.4	0588.2	0393.8	0750.4	0741.6	0518.0	0173.5
12:00:32	0	0	0788.6	0776.2	0679.4	0606.2	0589.4	0394.2	0750.0	0741.6	0518.0	0173.5
12:00:33	0	0	0789.0	0776.2	0679.8	0606.2	0589.0	0394.2	0750.4	0743.6	0518.0	0173.4
12:00:34	0	0	0789.0	0776.2	0679.8	0606.2	0589.0	0394.2	0750.0	0741.6	0518.4	0173.4
12:00:35	0	0	0788.6	0776.2	0678.2	0606.2	0589.0	0394.2	0750.0	0741.6	0518.0	0173.3
12:00:36	0	0	0789.4	0777.8	0678.6	0606.2	0589.0	0393.4	0749.6	0741.6	0518.0	0173.4
12:00:37	0	0	0788.6	0777.8	0679.4	0607.0	0589.0	0394.2	0749.6	0741.6	0516.8	0173.5
12:00:38	0	0	0788.6	0777.8	0679.0	0606.6	0589.0	0394.2	0750.4	0743.6	0518.0	0173.5
12:00:39	0	0	0789.0	0775.8	0679.4	0607.4	0589.0	0394.2	0750.0	0743.6	0517.6	0173.3
12:00:40	0	0	0787.0	0777.8	0679.8	0606.2	0589.0	0394.6	0749.6	0741.6	0518.0	0173.3
12:00:41	0	0	0788.6	0775.4	0679.4	0606.6	0589.0	0393.8	0750.0	0743.6	0518.0	0173.5
12:00:42	0	0	0788.6	0776.2	0679.4	0606.6	0589.0	0394.2	0749.6	0743.6	0518.0	0173.6
12:00:43	0	0	0787.8	0777.8	0679.4	0607.0	0592.2	0394.2	0750.0	0743.6	0518.0	0173.5
12:00:44	0	0	0787.0	0775.8	0680.2	0606.6	0589.0	0394.2	0749.6	0741.6	0518.4	0173.5
12:00:45	0	0	0789.0	0777.8	0678.6	0607.0	0589.0	0394.2	0750.0	0743.6	0518.0	0173.6
12:00:46	0	0	0788.2	0775.4	0679.4	0605.4	0589.4	0394.6	0749.6	0743.6	0518.0	0173.5
12:00:47	0	0	0788.6	0776.2	0679.4	0607.0	0589.0	0394.2	0749.6	0741.6	0517.6	0173.5
12:00:48	0	0	0788.2	0776.2	0679.4	0607.0	0589.0	0394.2	0749.6	0743.6	0517.6	0173.3
12:00:49	0	0	0788.6	0775.4	0679.4	0605.8	0589.0	0395.0	0749.6	0743.6	0518.0	0172.6
12:00:50	0	0	0788.6	0775.4	0679.4	0607.0	0589.0	0394.2	0749.6	0743.6	0517.6	0174.3
12:00:51	0	0	0787.8	0775.4	0679.8	0606.6	0589.0	0394.2	0751.6	0741.6	0518.0	0172.9
12:00:52	0	0	0787.0	0775.0	0679.4	0607.4	0589.0	0395.4	0749.2	0741.6	0518.0	0173.0
12:00:53	0	0	0787.0	0775.0	0679.4	0606.2	0589.0	0394.2	0749.6	0740.8	0518.0	0173.1

TABLE B-2. PRINTOUT OF 02 FOR RUN 13 (Continued)

FACC SMALL COMMUNITY SOLAR EXPERIMENT

PRINT: 02R DATE: 03/03/82 PAGE: 0001

TIME	RLS	WLS	CNEXTP DEG F	RLINTP DEG F	RLEXTP DEG F	ALTTP * DEG F	RCOTPR PSIA	TRINPR PSIA	TREXPR PSIA	CNEXPR PSIA	SYINPR PSIA	SYOTPR PSIA
12:00:00	0	0	0082.8	0091.6	0380.4	0056.6	0494.0	0410.8	0001.5	0001.1	0027.8	0527.6
12:00:01	0	0	0082.8	0091.7	0378.4	0056.6	0494.0	0415.0	0001.5	0001.1	0027.4	0528.4
12:00:02	0	0	0082.6	0091.7	0378.4	0056.5	0493.6	0410.0	0001.5	0001.1	0027.8	0528.0
12:00:03	0	0	0082.7	0091.7	0378.8	0056.5	0494.4	0410.4	0001.5	0001.1	0027.7	0528.0
12:00:04	0	0	0082.6	0091.7	0377.6	0056.5	0494.4	0409.6	0001.5	0001.1	0027.9	0527.2
12:00:05	0	0	0082.7	0091.7	0378.4	0056.5	0494.4	0413.2	0001.5	0001.1	0027.4	0528.8
12:00:06	0	0	0082.6	0091.4	0378.4	0056.6	0494.4	0410.8	0001.5	0001.1	0027.6	0528.8
12:00:07	0	0	0082.6	0091.7	0376.8	0056.4	0494.4	0410.8	0001.5	0001.1	0027.7	0528.8
12:00:08	0	0	0082.6	0091.5	0379.0	0056.6	0494.4	0410.8	0001.5	0001.1	0027.8	0528.4
12:00:09	0	0	0082.6	0091.5	0378.8	0056.4	0494.4	0411.2	0001.5	0001.1	0027.5	0528.4
12:00:10	0	0	0082.6	0091.5	0378.8	0056.2	0493.6	0414.4	0001.5	0001.1	0027.5	0529.2
12:00:11	0	0	0082.5	0091.4	0378.4	0056.5	0493.6	0412.8	0001.5	0001.1	0027.6	0528.0
12:00:12	0	0	0082.5	0091.4	0378.4	0056.7	0494.0	0417.6	0001.5	0001.1	0027.7	0528.8
12:00:13	0	0	0082.4	0091.0	0378.4	0056.6	0494.8	0411.6	0001.5	0001.1	0027.9	0528.4
12:00:14	0	0	0082.4	0091.4	0378.4	0056.4	0494.8	0410.8	0001.5	0001.1	0027.7	0528.0
12:00:15	0	0	0082.5	0091.5	0378.4	0056.6	0494.4	0410.4	0001.5	0001.1	0027.8	0528.0
12:00:16	0	0	0082.7	0091.3	0378.4	0056.2	0494.8	0409.6	0001.5	0001.1	0027.8	0528.0
12:00:17	0	0	0082.4	0091.4	0379.2	0056.7	0494.0	0414.0	0001.5	0001.1	0027.7	0527.6
12:00:18	0	0	0082.2	0091.3	0378.4	0056.6	0492.0	0410.4	0001.5	0001.1	0027.8	0528.4
12:00:19	0	0	0082.3	0091.3	0378.4	0056.6	0495.6	0410.8	0001.5	0001.1	0027.8	0527.6
12:00:20	0	0	0082.3	0091.2	0378.4	0056.7	0495.2	0402.8	0001.5	0001.1	0028.0	0527.6
12:00:21	0	0	0082.3	0091.3	0379.2	0056.6	0495.6	0415.6	0001.5	0001.1	0027.7	0528.4
12:00:22	0	0	0082.1	0091.2	0378.4	0056.7	0494.4	0410.4	0001.5	0001.1	0027.8	0527.6
12:00:23	0	0	0082.1	0091.1	0378.4	0056.7	0494.0	0414.4	0001.5	0001.1	0027.6	0529.2
12:00:24	0	0	0082.2	0091.1	0379.6	0056.6	0494.4	0410.8	0001.5	0001.1	0027.6	0528.4
12:00:25	0	0	0082.3	0091.0	0378.4	0056.6	0494.4	0415.6	0001.5	0001.1	0027.8	0528.4
12:00:26	0	0	0082.1	0091.0	0378.0	0056.7	0494.4	0410.8	0001.5	0001.1	0027.8	0528.4
12:00:27	0	0	0082.1	0091.0	0378.4	0056.6	0494.4	0406.0	0001.5	0001.1	0027.8	0527.2
12:00:28	0	0	0082.0	0091.0	0379.2	0056.6	0494.4	0412.4	0001.5	0001.1	0027.7	0528.4
12:00:29	0	0	0082.1	0091.0	0378.4	0056.8	0494.4	0410.8	0001.5	0001.1	0027.7	0528.0
12:00:30	0	0	0082.1	0091.1	0376.8	0056.6	0495.6	0406.0	0001.5	0001.1	0027.8	0527.2
12:00:31	0	0	0082.1	0090.9	0378.4	0056.6	0494.4	0410.6	0001.5	0001.1	0027.7	0528.0
12:00:32	0	0	0082.1	0091.1	0379.6	0057.5	0494.8	0412.8	0001.5	0001.1	0027.9	0528.8
12:00:33	0	0	0082.0	0090.9	0379.2	0056.6	0494.8	0409.2	0001.5	0001.1	0027.8	0528.4
12:00:34	0	0	0082.3	0090.9	0379.2	0056.6	0494.8	0410.8	0001.5	0001.1	0027.7	0528.4
12:00:35	0	0	0081.9	0090.8	0378.4	0056.6	0494.4	0410.8	0001.5	0001.1	0027.9	0528.8
12:00:36	0	0	0081.9	0090.9	0379.2	0056.9	0493.6	0418.8	0001.5	0001.1	0027.6	0528.8
12:00:37	0	0	0082.0	0090.7	0379.2	0056.6	0494.4	0415.6	0001.5	0001.1	0027.6	0529.2
12:00:38	0	0	0081.9	0090.9	0379.2	0056.6	0495.6	0412.4	0001.5	0001.1	0027.8	0527.6
12:00:39	0	0	0081.9	0090.8	0378.4	0056.6	0494.8	0410.8	0001.5	0001.1	0027.7	0528.8
12:00:40	0	0	0081.9	0090.7	0378.4	0056.7	0494.4	0418.0	0001.5	0001.1	0027.5	0528.8
12:00:41	0	0	0081.8	0090.8	0379.2	0056.8	0493.6	0419.6	0001.5	0001.1	0027.3	0528.8
12:00:42	0	0	0082.3	0090.6	0378.4	0056.6	0494.0	0412.4	0001.5	0001.1	0028.0	0527.6
12:00:43	0	0	0081.8	0090.7	0379.2	0056.7	0494.4	0412.4	0001.5	0001.1	0027.8	0527.6
12:00:44	0	0	0081.8	0090.6	0379.2	0056.7	0494.0	0415.6	0001.5	0001.1	0027.5	0527.6
12:00:45	0	0	0082.0	0090.9	0379.2	0056.8	0494.8	0410.8	0001.5	0001.1	0027.7	0529.2
12:00:46	0	0	0081.8	0090.6	0378.4	0056.6	0492.0	0406.8	0001.5	0001.1	0027.9	0527.6
12:00:47	0	0	0081.6	0090.7	0379.6	0056.7	0494.0	0413.6	0001.5	0001.1	0027.4	0527.6
12:00:48	0	0	0081.8	0090.6	0378.4	0056.7	0494.4	0413.2	0001.5	0001.1	0027.5	0528.4
12:00:49	0	0	0081.8	0090.5	0378.4	0056.7	0492.4	0411.2	0001.5	0001.1	0027.5	0528.4
12:00:50	0	0	0081.9	0090.5	0379.2	0056.7	0493.6	0418.8	0001.5	0001.1	0027.3	0528.0
12:00:51	0	0	0081.8	0090.5	0379.2	0056.7	0493.2	0410.8	0001.5	0001.1	0027.7	0529.2
12:00:52	0	0	0081.4	0090.2	0378.4	0056.6	0494.8	0409.6	0001.5	0001.1	0027.9	0527.6
12:00:53	0	0	0081.8	0090.5	0378.4	0056.7	0494.8	0406.0	0001.5	0001.1	0027.9	0528.0

* Thermocouple inoperative

PRINT 03 DESCRIPTION - OTHER PCA MEASUREMENTS

Print No.	Parameter	Description
03L	RCOTPR*	Receiver outlet pressure
03L	RCOTTP*	Receiver fluid outlet temp.
03L	TRVLPC	Vapor valve position command
03L	TRVLP	Vapor valve position
03L	TDAC1	Test channel (= RCOTPR)
03L	TDAC2	Test channel (= TRVLP)
03L	RCSTP5*	Receiver shell temp., location 5
03L	TURPM	Turbine (alternator) speed
03L	REOTCR**	Rectifier output current
03L	RESLVL	Reservoir fluid level
03R	DELT	Shell temp. rise in 100 sec.
03R	TCURR	Current average shell temp.
03R	ADCAL	A/D calibration check signal
03R	REOTVT**	Rectifier output voltage
03R	SETP	Setpoint used in control of receiver outlet temp.
03R	PPMODS	RCIA/PCA modes***
03R	DSEVT1	RCIA discrete events No. 1***
03R	RCSTP3*	Receiver shell temp., location 3
03R	RTDRS1	Receiver shell temp. using RTD No. 1 (location 3, temp. No. 7)
03R	RTDRS2	Receiver shell temp. using RTD No. 2 (location 3, temp. No. 8)

*Repeated from Print 02

** Unreliable sensor

***See TR-SCSE-027E (Ref. 22) for a definition of these modes and events

TABLE B-3. PRINTOUT OF 03 FOR RUN 13

FACC SMALL COMMUNITY SOLAR EXPERIMENT
DATE: 03/03/82

PRINT: 03L

TIME	RLS	WLS	RCOTPR PSIA	RCOTTP DEG F	TRVLPC PERCENT	TRVLP PERCENT	TDAC1	TDAC2	RCSTP5 DEG F	TURPM KRPM	REDTCR AMPS	RESLVL PERCENT
12:00:00	0	0	0494.0	0750.4	0048.3	0047.3	0494.0	0047.3	0589.0	0047.6	0029.8	0078.2
12:00:01	0	0	0494.0	0750.0	0048.2	0047.7	0494.0	0047.7	0589.0	0047.6	0029.8	0076.0
12:00:02	0	0	0493.6	0750.4	0048.1	0047.2	0493.6	0047.2	0589.0	0047.6	0029.6	0078.3
12:00:03	0	0	0494.4	0750.4	0048.3	0047.4	0494.4	0047.4	0589.0	0047.6	0030.0	0078.3
12:00:04	0	0	0494.4	0750.4	0048.3	0047.4	0494.4	0047.4	0589.0	0047.6	0029.9	0078.1
12:00:05	0	0	0494.4	0750.4	0048.3	0047.4	0494.4	0047.4	0589.0	0047.6	0030.0	0077.7
12:00:06	0	0	0494.4	0750.4	0048.3	0047.4	0494.4	0047.4	0589.4	0047.6	0029.8	0078.1
12:00:07	0	0	0494.4	0749.6	0048.1	0047.2	0494.4	0047.2	0589.0	0047.6	0029.7	0078.3
12:00:08	0	0	0494.4	0750.8	0048.1	0047.3	0494.4	0047.3	0589.0	0047.6	0029.3	0077.8
12:00:09	0	0	0494.4	0749.6	0048.0	0047.3	0494.4	0047.3	0589.0	0047.6	0029.0	0077.0
12:00:10	0	0	0493.6	0750.4	0048.4	0047.6	0493.6	0047.6	0589.0	0047.6	0029.5	0077.4
12:00:11	0	0	0493.6	0748.0	0047.8	0047.4	0493.6	0047.4	0588.2	0047.6	0030.2	0077.7
12:00:12	0	0	0494.0	0750.0	0048.3	0047.7	0494.0	0047.7	0589.0	0047.8	0028.9	0077.7
12:00:13	0	0	0494.8	0750.4	0048.2	0047.4	0494.8	0047.4	0589.0	0047.6	0029.8	0077.4
12:00:14	0	0	0494.8	0750.4	0048.4	0047.4	0494.8	0047.4	0589.0	0047.6	0028.6	0076.7
12:00:15	0	0	0494.4	0750.4	0048.2	0047.4	0494.4	0047.4	0589.0	0047.6	0029.6	0077.4
12:00:16	0	0	0494.8	0750.4	0048.3	0047.3	0494.8	0047.3	0589.0	0047.6	0030.0	0077.7
12:00:17	0	0	0494.0	0750.4	0048.4	0047.6	0494.0	0047.6	0589.0	0047.6	0029.4	0077.0
12:00:18	0	0	0492.0	0750.4	0048.2	0047.4	0492.0	0047.4	0589.0	0047.8	0029.4	0077.0
12:00:19	0	0	0495.6	0750.4	0048.1	0047.4	0495.6	0047.4	0589.0	0047.6	0029.0	0077.5
12:00:20	0	0	0495.2	0750.8	0048.3	0046.6	0495.2	0046.6	0589.8	0047.4	0029.3	0077.8
12:00:21	0	0	0495.6	0750.4	0048.5	0047.6	0495.6	0047.6	0589.0	0047.8	0029.4	0077.1
12:00:22	0	0	0494.4	0750.4	0048.2	0047.4	0494.4	0047.4	0589.0	0047.6	0029.8	0078.0
12:00:23	0	0	0494.0	0750.0	0048.4	0047.6	0494.0	0047.6	0589.0	0047.6	0029.0	0078.8
12:00:24	0	0	0494.4	0749.6	0048.0	0047.3	0494.4	0047.3	0589.0	0047.6	0030.0	0077.3
12:00:25	0	0	0494.4	0750.4	0048.1	0047.6	0494.4	0047.6	0589.0	0047.6	0029.4	0077.1
12:00:26	0	0	0494.4	0750.4	0048.1	0047.4	0494.4	0047.4	0589.0	0047.6	0029.5	0077.5
12:00:27	0	0	0494.4	0750.4	0048.5	0047.1	0494.4	0047.1	0589.0	0047.6	0029.7	0077.2
12:00:28	0	0	0494.4	0750.0	0048.3	0047.4	0494.4	0047.4	0589.0	0047.8	0029.8	0077.2
12:00:29	0	0	0494.4	0749.6	0048.0	0047.3	0494.4	0047.3	0589.0	0047.6	0029.3	0077.3
12:00:30	0	0	0495.6	0750.0	0048.1	0047.0	0495.6	0047.0	0589.0	0047.6	0029.2	0077.1
12:00:31	0	0	0494.4	0750.4	0048.1	0047.4	0494.4	0047.4	0588.2	0047.6	0029.6	0077.3
12:00:32	0	0	0494.8	0750.0	0048.3	0047.6	0494.8	0047.6	0589.4	0047.6	0029.6	0077.4
12:00:33	0	0	0494.8	0750.4	0048.0	0047.2	0494.8	0047.2	0589.0	0047.6	0029.2	0077.0
12:00:34	0	0	0494.8	0750.0	0048.0	0047.4	0494.8	0047.4	0589.0	0047.6	0029.3	0076.9
12:00:35	0	0	0494.4	0750.0	0048.1	0047.4	0494.4	0047.4	0589.0	0047.6	0028.5	0077.0
12:00:36	0	0	0493.6	0749.6	0048.2	0048.0	0493.6	0048.0	0589.0	0047.8	0029.4	0077.8
12:00:37	0	0	0494.4	0749.6	0048.1	0047.4	0494.4	0047.4	0589.0	0047.6	0030.0	0077.7
12:00:38	0	0	0495.6	0750.4	0048.0	0047.4	0495.6	0047.4	0589.0	0047.6	0029.5	0077.0
12:00:39	0	0	0494.8	0750.0	0048.1	0047.4	0494.8	0047.4	0589.0	0047.6	0029.1	0077.1
12:00:40	0	0	0494.4	0749.6	0048.1	0047.7	0494.4	0047.7	0589.0	0047.8	0029.7	0077.2
12:00:41	0	0	0493.6	0750.0	0048.3	0047.8	0493.6	0047.8	0589.0	0047.8	0030.1	0077.0
12:00:42	0	0	0494.0	0749.6	0048.4	0047.4	0494.0	0047.4	0589.0	0047.6	0029.3	0077.4
12:00:43	0	0	0494.4	0750.0	0049.1	0047.6	0494.4	0047.6	0592.2	0047.6	0029.4	0077.7
12:00:44	0	0	0494.0	0749.6	0048.1	0047.4	0494.0	0047.4	0589.0	0047.6	0030.0	0076.7
12:00:45	0	0	0494.8	0750.0	0047.9	0047.4	0494.8	0047.4	0589.0	0047.6	0030.1	0077.0
12:00:46	0	0	0492.0	0749.6	0048.4	0047.0	0492.0	0047.0	0589.4	0047.6	0028.6	0077.5
12:00:47	0	0	0494.0	0749.6	0048.2	0047.4	0494.0	0047.4	0589.0	0047.6	0030.2	0076.9
12:00:48	0	0	0494.4	0749.6	0048.0	0047.4	0494.4	0047.4	0589.0	0047.8	0029.0	[illegible]
12:00:49	0	0	0492.4	0749.6	0049.2	0047.3	0492.4	0047.3	0589.0	0047.6	0029.7	[illegible]
12:00:50	0	0	0493.6	0749.6	0048.1	0047.7	0493.6	0047.7	0589.0	0047.6	0030.6	0077.1
12:00:51	0	0	0493.2	0751.6	0048.2	0047.4	0493.2	0047.4	0589.0	0047.6	0029.6	0077.2
12:00:52	0	0	0494.8	0749.2	0047.8	0047.2	0494.8	0047.2	0589.0	0047.6	0029.2	0077.0
12:00:53	0	0	0494.8	0749.6	0048.0	0047.0	0494.8	0047.0	0589.0	0047.6	0028.9	0077.1

TABLE B-3. PRINTOUT OF 03 FOR RUN 13 (Continued)

FACC SMALL COMMUNITY SOLAR EXPERIMENT

PRINT: 03R DATE: 03/03/82 PAGE: 0001

TIME	RLS	WLS	DELT DEGS	TCURR DEG F	ADCAL	REDTVT VOLTS	SETP DEGS	RPMODS EVENTS	DSEVT1 EVENTS	RCSTP3 DEG F	RTDRS1 DEG F	RTDRS2 DEG F
12:00:00	0	0	-0008.2	0610.0	0155.6	0468.8	0590.3	00000010	00000110	0679.8	0692.0	0692.8
12:00:01	0	0	-0009.2	0608.9	0155.6	0452.8	0590.3	00000010	00000110	0679.8	0692.0	0691.6
12:00:02	0	0	-0010.0	0609.5	0155.6	0480.4	0590.3	00000010	00000110	0679.8	0692.4	0692.4
12:00:03	0	0	-0010.6	0609.2	0155.6	0483.6	0590.3	00000010	00000110	0679.8	0692.0	0690.4
12:00:04	0	0	-0011.2	0609.7	0155.6	0464.4	0590.3	00000010	00000110	0679.8	0691.6	0691.2
12:00:05	0	0	-0012.0	0609.1	0155.5	0464.0	0590.3	00000010	00000110	0679.8	0692.0	0691.6
12:00:06	0	0	-0012.6	0608.9	0155.8	0474.0	0590.3	00000010	00000110	0679.4	0692.0	0692.0
12:00:07	0	0	-0013.0	0609.1	0155.7	0466.4	0590.3	00000010	00000110	0679.8	0692.0	0692.0
12:00:08	0	0	-0013.0	0609.0	0155.6	0480.0	0590.3	00000010	00000110	0679.8	0692.0	0692.0
12:00:09	0	0	-0012.6	0609.7	0155.7	0463.6	0590.3	00000010	00000110	0679.8	0692.0	0691.6
12:00:10	0	0	-0012.4	0609.5	0155.6	0488.0	0590.3	00000010	00000110	0679.8	0692.0	0691.6
12:00:11	0	0	-0012.4	0609.3	0155.6	0468.0	0590.3	00000010	00000110	0679.8	0692.0	0691.6
12:00:12	0	0	-0012.6	0609.4	0155.1	0466.4	0590.3	00000010	00000110	0679.8	0691.6	0692.0
12:00:13	0	0	-0013.0	0608.9	0155.6	0470.0	0590.3	00000010	00000110	0679.0	0691.6	0691.6
12:00:14	0	0	-0013.0	0609.1	0155.6	0474.0	0590.3	00000010	00000110	0679.8	0692.0	0692.0
12:00:15	0	0	-0012.8	0609.4	0155.6	0468.4	0590.3	00000010	00000110	0679.8	0693.2	0692.0
12:00:16	0	0	-0012.4	0609.3	0155.6	0462.0	0590.3	00000010	00000110	0679.8	0692.0	0690.4
12:00:17	0	0	-0012.0	0609.4	0155.6	0476.4	0590.3	00000010	00000110	0679.8	0692.0	0691.6
12:00:18	0	0	-0012.0	0609.4	0155.6	0460.0	0590.3	00000010	00000110	0679.8	0692.0	0691.6
12:00:19	0	0	-0012.0	0608.9	0155.6	0471.6	0590.3	00000010	00000110	0679.8	0691.6	0691.6
12:00:20	0	0	-0011.8	0609.2	0155.6	0469.6	0590.3	00000010	00000110	0679.8	0691.6	0691.6
12:00:21	0	0	-0011.4	0609.2	0155.6	0462.8	0590.3	00000010	00000110	0680.2	0691.6	0691.6
12:00:22	0	0	-0010.8	0609.3	0155.6	0476.0	0590.3	00000010	00000110	0679.8	0691.6	0691.6
12:00:23	0	0	-0010.4	0609.4	0155.6	0430.0	0590.3	00000010	00000110	0679.8	0692.4	0691.2
12:00:24	0	0	-0010.2	0609.1	0155.6	0470.4	0590.3	00000010	00000110	0679.4	0691.6	0694.0
12:00:25	0	0	-0009.8	0609.1	0155.6	0475.2	0590.3	00000010	00000110	0679.8	0691.2	0690.4
12:00:26	0	0	-0009.6	0609.4	0155.6	0475.2	0590.3	00000010	00000110	0679.0	0691.6	0691.6
12:00:27	0	0	-0009.6	0609.0	0155.6	0474.0	0590.3	00000010	00000110	0679.4	0691.6	0691.6
12:00:28	0	0	-0009.8	0608.9	0155.8	0471.6	0590.3	00000010	00000110	0679.8	0691.6	0692.0
12:00:29	0	0	-0009.8	0609.6	0155.6	0478.4	0590.3	00000010	00000110	0679.4	0691.6	0691.6
12:00:30	0	0	-0010.2	0609.1	0155.1	0461.2	0590.3	00000010	00000110	0679.4	0691.2	0691.6
12:00:31	0	0	-0010.6	0608.9	0155.6	0476.0	0590.3	00000010	00000110	0677.4	0691.6	0691.6
12:00:32	0	0	-0010.8	0608.7	0155.6	0466.0	0590.3	00000010	00000110	0679.4	0691.6	0690.8
12:00:33	0	0	-0010.8	0608.9	0155.6	0489.2	0590.3	00000010	00000110	0679.8	0691.2	0691.6
12:00:34	0	0	-0010.8	0609.0	0155.6	0485.6	0590.3	00000010	00000110	0679.8	0691.6	0691.6
12:00:35	0	0	-0011.0	0609.0	0155.6	0462.4	0590.3	00000010	00000110	0678.2	0691.2	0691.2
12:00:36	0	0	-0011.2	0608.7	0155.6	0466.4	0590.3	00000010	00000110	0678.6	0691.2	0691.6
12:00:37	0	0	-0011.2	0609.0	0155.6	0460.4	0590.3	00000010	00000110	0679.4	0691.2	0690.8
12:00:38	0	0	-0011.2	0609.4	0155.1	0470.0	0590.3	00000010	00000110	0679.0	0691.6	0691.6
12:00:39	0	0	-0011.4	0609.3	0155.6	0463.6	0590.3	00000010	00000110	0679.4	0691.6	0691.6
12:00:40	0	0	-0011.4	0609.1	0155.6	0455.6	0590.3	00000010	00000110	0679.8	0691.2	0690.4
12:00:41	0	0	-0011.4	0609.4	0155.6	0466.0	0590.3	00000010	00000110	0679.4	0691.2	0690.8
12:00:42	0	0	-0011.4	0608.8	0155.6	0477.2	0590.3	00000010	00000110	0679.4	0691.2	0691.6
12:00:43	0	0	-0011.0	0609.1	0155.6	0461.2	0590.3	00000010	00000110	0679.4	0691.2	0690.8
12:00:44	0	0	-0010.6	0609.3	0155.6	0455.2	0590.3	00000010	00000110	0680.2	0691.6	0690.8
12:00:45	0	0	-0010.2	0609.1	0155.6	0462.4	0590.3	00000010	00000110	0678.6	0691.2	0691.6
12:00:46	0	0	-0009.8	0609.3	0155.6	0466.4	0590.3	00000010	00000110	0679.4	0691.2	0690.4
12:00:47	0	0	-0009.6	0608.7	0155.6	0466.4	0590.3	00000010	00000110	0679.4	0692.4	0691.6
12:00:48	0	0	-0009.4	0609.1	0155.6	0468.8	0590.3	00000010	00000110	0679.4	0691.2	0690.0
12:00:49	0	0	-0009.4	0609.1	0155.6	0472.0	0590.3	00000010	00000110	0679.4	0691.2	0691.2
12:00:50	0	0	-0009.6	0608.9	0155.6	0456.8	0590.3	00000010	00000110	0679.4	0691.6	0690.8
12:00:51	0	0	-0009.8	0608.9	0155.1	0476.8	0590.3	00000010	00000110	0679.8	0691.2	0690.4
12:00:52	0	0	-0010.0	0608.9	0155.6	0464.8	0590.3	00000010	00000110	0679.4	0690.4	0690.8
12:00:53	0	0	-0010.0	0609.2	0155.6	0466.4	0590.3	00000010	00000110	0679.4	0690.4	0690.4

PRINT 04 DESCRIPTION - PCS EVENTS (DISCRETES)

Print No.	Parameter*	Description
04L	PPMODS**	RCIA/PCA modes
04L	FLTDAT	PCA fault summary
04L	DSCMD1	RCIA discrete commands No. 1
04L	DSCMD2	RCIA discrete commands No. 2
04L	DSEVT1**	RCIA discrete events No. 1
04L	DSEVT2	RCIA discrete events No. 2
04L	PCAFL1	PCA faults No. 1
04L	PCAFL2	PCA faults No. 1
04L	RCFLTS	RCIA faults
04L	CHNERR	Analog error channel No.
04R	RCIACD	RCIA discrete commands No. 1
04R	RCIAC2	RCIA discrete commands No. 2
04R	ETSEV1	ETS discrete events No. 1
04R	ETSEV2	ETS discrete events No. 2 (not used)

*These parameters are defined in TR-SCSE-027E (Ref. 22) or Ref. 21

**Repeated from Print 03R

TABLE B-4. PRINTOUT OF 04 FOR RUN 13

FACC SMALL COMMUNITY SOLAR EXPERIMENT

PRINT: 04L DATE: 03/03/82 PAGE: 0001

TIME	RLS	WLS	RPMODS EVENTS	FLTDAT EVENTS	DSCMD1 EVENTS	DSCMD2 EVENTS	DSEVT1 EVENTS	DSEVT2 EVENTS	PCAFL1 EVENTS	PCAFL2 EVENTS	RCFLTS EVENTS	CHNERR
12:00:00	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:01	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:02	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:03	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:04	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:05	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:06	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:07	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:08	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:09	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:10	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:11	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:12	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:13	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:14	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:15	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:16	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:17	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:18	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:19	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:20	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:21	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:22	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:23	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:24	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:25	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:26	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:27	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:28	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:29	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:30	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:31	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:32	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:33	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:34	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:35	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:36	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:37	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:38	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:39	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:40	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:41	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:42	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:43	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:44	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:45	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:46	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:47	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:48	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:49	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:50	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:51	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:52	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0
12:00:53	0	0	00000010	00000000	11110110	20001001	00000110	01011100	00000000	00000000	00000000	0000.0

TABLE B-4. PRINTOUT OF 04 FOR RUN 13 (Continued)

FACC SMALL COMMUNITY SOLAR EXPERIMENT

PRINT: 04R DATE: 03/03/82

TIME	RLS	WLS	RCIACD EVENTS	RCIAC2 EVENTS	ETSEV1 EVENTS	ETSEV2 EVENTS
12:00:00	0	0	01000000	00000000	/0110111	
12:00:01	0	0	01000000	00000000	/0110111	
12:00:02	0	0	01000000	00000000	/0110111	
12:00:03	0	0	01000000	00000000	/0110111	
12:00:04	0	0	01000000	00000000	/0110111	
12:00:05	0	0	01000000	00000000	/0110111	
12:00:06	0	0	01000000	00000000	/0110111	
12:00:07	0	0	01000000	00000000	/0110111	
12:00:08	0	0	01000000	00000000	/0110111	
12:00:09	0	0	01000000	00000000	/0110111	
12:00:10	0	0	01000000	00000000	/0110111	
12:00:11	0	0	01000000	00000000	/0110111	
12:00:12	0	0	01000000	00000000	/0110111	
12:00:13	0	0	01000000	00000000	/0110111	
12:00:14	0	0	01000000	00000000	/0110111	
12:00:15	0	0	01000000	00000000	/0110111	
12:00:16	0	0	01000000	00000000	/0110111	
12:00:17	0	0	01000000	00000000	/0110111	
12:00:18	0	0	01000000	00000000	/0110111	
12:00:19	0	0	01000000	00000000	/0110111	
12:00:20	0	0	01000000	00000000	/0110111	
12:00:21	0	0	01000000	00000000	/0110111	
12:00:22	0	0	01000000	00000000	/0110111	
12:00:23	0	0	01000000	00000000	/0110111	
12:00:24	0	0	01000000	00000000	/0110111	
12:00:25	0	0	01000000	00000000	/0110111	
12:00:26	0	0	01000000	00000000	/0110111	
12:00:27	0	0	01000000	00000000	/0110111	
12:00:28	0	0	01000000	00000000	/0110111	
12:00:29	0	0	01000000	00000000	/0110111	
12:00:30	0	0	01000000	00000000	/0110111	
12:00:31	0	0	01000000	00000000	/0110111	
12:00:32	0	0	01000000	00000000	/0110111	
12:00:33	0	0	01000000	00000000	/0110111	
12:00:34	0	0	01000000	00000000	/0110111	
12:00:35	0	0	01000000	00000000	/0110111	
12:00:36	0	0	01000000	00000000	/0110111	
12:00:37	0	0	01000000	00000000	/0110111	
12:00:38	0	0	01000000	00000000	/0110111	
12:00:39	0	0	01000000	00000000	/0110111	
12:00:40	0	0	01000000	00000000	/0110111	
12:00:41	0	0	01000000	00000000	/0110111	
12:00:42	0	0	01000000	00000000	/0110111	
12:00:43	0	0	01000000	00000000	/0110111	
12:00:44	0	0	01000000	00000000	/0110111	
12:00:45	0	0	01000000	00000000	/0110111	
12:00:46	0	0	01000000	00000000	/0110111	
12:00:47	0	0	01000000	00000000	/0110111	
12:00:48	0	0	01000000	00000000	/0110111	
12:00:49	0	0	01000000	00000000	/0110111	
12:00:50	0	0	01000000	00000000	/0110111	
12:00:51	0	0	01000000	00000000	/0110111	
12:00:52	0	0	01000000	00000000	/0110111	
12:00:53	0	0	01000000	00000000	/0110111	

PRINT 05 DESCRIPTION - ETS DATA

Print No.	Parameter	Description
05L	INDCAM	Inverter input current (dc)
05L	INDCVL	Inverter input voltage (dc)
05L	INOTP1*	Inverter output voltage, Phase 1 (ac)
05L	INOTP2*	Inverter output voltage, Phase 2 (ac)
05L	INOTP3*	Inverter output voltage, Phase 3 (ac)
05L	INVA1	Inverter output current, Phase 1 (ac)
05L	INVA2	Inverter output current, Phase 2 (ac)
05L	INVA3	Inverter output current, Phase 3 (ac)
05L	INVPF1*	Inverter output power factor, Phase 1
05L	ETSEV1**	ETS discrete events No. 1
05R	PYRHL4***	Local Eppley pyrheliometer reading
05R	AMBTMP	Ambient temperature (from weather station)
05R	ADCAL****	A/D calibration check signal
05R	ALTVL1	Alternator voltage Phase 1
05R	ALTVL2	Alternator voltage, Phase 2
05R	ALTVL3	Alternator voltage, Phase 3

*Valid only when inverter connected to the grid. Final sensor calibration completed after these tests were completed.

**Repeated from Print 04R

***Repeated from Print 01L; same as PM1

****Repeated from print 03R

TABLE B-5. PRINTOUT OF 05 FOR RUN 13

FACC SMALL COMMUNITY SOLAR EXPERIMENT

PRINT: 05L DATE: 03/03/82 PAGE: 0001

TIME	RLS	WLS	INDCAM AMPS	INDCVL VOLTS	INDTP1* VOLTS	INDTP2* VOLTS	INDTP3* VOLTS	INVA1 AMPS	INVA2 AMPS	INVA3 AMPS	INVPF1*	ETSEV1 EVENTS
12:00:00	0	0	0032.2	0503.2	0001.0	0000.0	0004.2	0023.9	0024.7	0024.5	-0086.5	/0110111
12:00:01	0	0	0032.5	0500.1	0004.5	0000.0	0000.1	0024.7	0024.5	0024.0	-0088.4	/0110111
12:00:02	0	0	0032.5	0505.0	0001.7	0000.0	0000.0	0024.9	0024.4	0024.0	-0088.5	/0110111
12:00:03	0	0	0032.3	0498.6	0000.4	0000.4	0000.0	0024.0	0024.5	0024.8	-0086.4	/0110111
12:00:04	0	0	0031.9	0503.7	0002.4	0000.0	0000.1	0024.8	0023.6	0024.7	-0086.9	/0110111
12:00:05	0	0	0032.1	0498.4	0002.6	0000.0	0000.0	0024.4	0024.6	0024.0	-0086.4	/0110111
12:00:06	0	0	0032.3	0498.9	0000.0	0000.0	0001.3	0024.7	0023.6	0024.9	-0087.8	/0110111
12:00:07	0	0	0032.4	0499.8	0004.1	0000.0	0000.4	0024.9	0024.3	0023.9	-0088.4	/0110111
12:00:08	0	0	0032.4	0498.1	0000.7	0000.0	0001.6	0024.1	0024.7	0024.3	-0088.6	/0110111
12:00:09	0	0	0032.6	0499.1	0000.0	0000.0	0001.3	0024.7	0023.9	0025.3	-0087.7	/0110111
12:00:10	0	0	0032.2	0501.3	0002.1	0000.1	0000.0	0024.4	0024.6	0024.0	-0086.3	/0110111
12:00:11	0	0	0032.3	0499.6	0003.3	0000.0	0000.0	0024.3	0023.8	0025.1	-0087.1	/0110111
12:00:12	0	0	0032.4	0501.8	0000.0	0000.0	0000.1	0024.7	0023.6	0024.9	-0087.8	/0110111
12:00:13	0	0	0032.4	0497.9	0000.4	0000.0	0001.9	0024.1	0024.7	0024.4	-0088.5	/0110111
12:00:14	0	0	0032.0	0502.8	0000.4	0000.0	0003.6	0024.0	0024.2	0024.8	-0087.9	/0110111
12:00:15	0	0	0032.0	0498.6	0006.4	0003.2	0001.4	0024.9	0023.7	0024.4	-0086.3	/0110111
12:00:16	0	0	0032.5	0497.4	0001.4	0000.0	0000.4	0024.4	0023.8	0025.2	-0087.0	/0110111
12:00:17	0	0	0032.3	0498.6	0001.6	0000.0	0001.7	0024.3	0023.7	0025.0	-0087.2	/0110111
12:00:18	0	0	0032.0	0497.6	0002.0	0000.0	0000.1	0024.9	0023.9	0023.9	-0088.7	/0110111
12:00:19	0	0	0032.0	0499.8	0000.8	0000.4	0004.3	0024.2	0023.8	0025.0	-0087.5	/0110111
12:00:20	0	0	0032.5	0504.0	0002.7	0000.0	0000.0	0025.0	0023.8	0025.0	-0086.9	/0110111
12:00:21	0	0	0032.2	0499.3	0002.3	0000.0	0003.0	0023.9	0024.6	0024.6	-0086.3	/0110111
12:00:22	0	0	0032.8	0500.1	0001.0	0000.0	0001.4	0024.8	0023.8	0025.2	-0087.7	/0110111
12:00:23	0	0	0032.4	0501.8	0000.7	0000.0	0001.4	0025.0	0023.9	0024.1	-0088.6	/0110111
12:00:24	0	0	0032.2	0499.8	0000.4	0000.0	0001.7	0023.9	0024.7	0024.3	-0088.6	/0110111
12:00:25	0	0	0032.0	0503.0	0003.6	0005.5	0001.3	0024.5	0023.6	0025.0	-0087.1	/0110111
12:00:26	0	0	0032.3	0503.0	0000.8	0000.1	0000.5	0024.0	0024.8	0024.4	-0086.0	/0110111
12:00:27	0	0	0032.3	0504.2	0000.0	0000.1	0001.3	0024.0	0024.5	0024.8	-0086.4	/0110111
12:00:28	0	0	0032.3	0500.8	0000.1	0000.0	0001.0	0025.0	0024.1	0024.0	-0088.6	/0110111
12:00:29	0	0	0032.4	0504.0	0001.1	0000.0	0000.2	0024.4	0024.6	0024.1	-0088.5	/0110111
12:00:30	0	0	0032.0	0505.0	0001.4	0000.4	0000.0	0024.2	0023.8	0025.0	-0087.6	/0110111
12:00:31	0	0	0032.1	0504.0	0000.4	0001.4	0000.4	0024.0	0024.7	0024.2	-0086.0	/0110111
12:00:32	0	0	0032.2	0498.4	0002.9	0000.0	0000.0	0024.1	0024.8	0024.4	-0086.2	/0110111
12:00:33	0	0	0032.4	0497.4	0000.0	0000.0	0001.6	0024.6	0023.7	0025.1	-0087.7	/0110111
12:00:34	0	0	0032.4	0500.1	0000.0	0000.0	0002.1	0024.9	0024.2	0023.9	-0088.4	/0110111
12:00:35	0	0	0032.6	0502.0	0001.9	0000.1	0000.0	0024.1	0024.5	0025.0	-0088.3	/0110111
12:00:36	0	0	0032.1	0497.4	0003.0	0000.0	0001.0	0025.0	0024.2	0023.9	-0086.2	/0110111
12:00:37	0	0	0032.2	0500.3	0001.9	0000.0	0000.0	0023.9	0024.7	0024.5	-0086.4	/0110111
12:00:38	0	0	0032.6	0504.2	0000.7	0000.0	0000.0	0024.2	0024.1	0025.1	-0087.1	/0110111
12:00:39	0	0	0033.3	0503.7	0001.3	0000.0	0001.7	0025.4	0024.2	0024.5	-0088.6	/0110111
12:00:40	0	0	0032.2	0498.4	0002.7	0000.0	0000.5	0024.0	0024.3	0024.9	-0088.3	/0110111
12:00:41	0	0	0032.5	0499.3	0001.7	0000.2	0000.0	0025.2	0024.1	0024.3	-0086.0	/0110111
12:00:42	0	0	0033.2	0503.2	0000.0	0000.0	0001.9	0025.3	0024.8	0024.3	-0086.3	/0110111
12:00:43	0	0	0032.4	0499.6	0005.8	0000.0	0000.2	0024.3	0023.8	0025.1	-0087.1	/0110111
12:00:44	0	0	0031.7	0500.8	0002.4	0000.0	0000.4	0024.6	0023.4	0024.2	-0088.4	/0110111
12:00:45	0	0	0033.2	0503.2	0005.4	0000.1	0000.2	0024.6	0025.0	0024.5	-0088.5	/0110111
12:00:46	0	0	0032.5	0504.5	0003.3	0001.3	0000.0	0025.1	0024.3	0024.1	-0086.0	/0110111
12:00:47	0	0	0032.1	0498.9	0002.0	0000.0	0000.7	0025.0	0024.2	0023.9	-0086.4	/0110111
12:00:48	0	0	0033.9	0501.8	0002.1	0000.0	0001.0	0024.9	0024.5	0025.8	-0087.0	/0110111
12:00:49	0	0	0032.3	0502.8	0001.3	0000.2	0000.0	0025.0	0023.9	0024.0	-0088.6	/0110111
12:00:50	0	0	0032.2	0497.4	0000.4	0001.0	0000.0	0023.9	0024.6	0024.5	-0088.2	/0110111
12:00:51	0	0	0031.5	0498.4	0001.7	0001.7	0000.0	0024.3	0023.4	0024.8	-0086.9	/0110111
12:00:52	0	0	0032.2	0497.4	0002.1	0000.0	0001.6	0025.0	0024.1	0024.0	-0086.0	/0110111
12:00:53	0	0	0032.1	0498.9	0001.6	0000.0	0000.1	0024.5	0024.5	0024.0	-0086.3	/0110111

*Not valid for these tests

TABLE B-5. PRINTOUT OF 05 FOR RUN 13 (Continued)

FACC SMALL COMMUNITY SOLAR EXPERIMENT

PRINT: 05R DATE: 03/03/82 PAGE: 0001

TIME	RLS	WLS	PYRHL4 W/M*M	AMBTMP DEG F	ADCAL	ALTVL1 VOLTS	ALTVL2 VOLTS	ALTVL3 VOLTS
12:00:00	0	0	0982.8	0054.5	0155.6	0236.4	0236.0	0238.0
12:00:01	0	0	0982.5	0054.5	0155.6	0237.4	0236.4	0238.6
12:00:02	0	0	0982.8	0054.5	0155.6	0237.4	0236.2	0238.4
12:00:03	0	0	0982.8	0054.5	0155.6	0237.2	0236.2	0238.6
12:00:04	0	0	0982.8	0054.5	0155.6	0237.2	0236.2	0238.2
12:00:05	0	0	0982.5	0054.5	0155.5	0237.4	0236.6	0238.4
12:00:06	0	0	0982.5	0054.5	0155.8	0237.4	0236.2	0238.2
12:00:07	0	0	0982.8	0054.5	0155.7	0237.4	0236.2	0238.4
12:00:08	0	0	0983.4	0054.5	0155.6	0237.8	0236.2	0238.4
12:00:09	0	0	0983.1	0054.5	0155.7	0237.4	0236.2	0238.2
12:00:10	0	0	0983.4	0054.5	0155.6	0237.2	0236.2	0238.6
12:00:11	0	0	0982.8	0054.5	0155.6	0237.4	0236.2	0238.4
12:00:12	0	0	0982.8	0054.5	0155.1	0237.6	0236.2	0238.4
12:00:13	0	0	0982.5	0054.5	0155.6	0237.2	0236.4	0238.4
12:00:14	0	0	0983.1	0054.5	0155.6	0237.4	0236.2	0238.2
12:00:15	0	0	0982.5	0054.5	0155.6	0237.2	0236.2	0238.4
12:00:16	0	0	0982.8	0054.5	0155.6	0237.0	0235.8	0238.2
12:00:17	0	0	0982.8	0054.5	0155.6	0237.8	0236.0	0238.4
12:00:18	0	0	0983.1	0054.5	0155.6	0237.4	0236.2	0238.0
12:00:19	0	0	0982.8	0054.5	0155.6	0237.4	0235.6	0238.0
12:00:20	0	0	0982.8	0054.5	0155.6	0236.8	0234.8	0238.0
12:00:21	0	0	0982.8	0054.5	0155.6	0237.4	0236.0	0238.0
12:00:22	0	0	0983.1	0054.5	0155.6	0237.4	0235.6	0238.0
12:00:23	0	0	0982.8	0054.5	0155.6	0237.4	0235.6	0238.4
12:00:24	0	0	0983.1	0054.5	0155.6	0237.2	0236.2	0239.0
12:00:25	0	0	0983.1	0054.5	0155.6	0236.8	0236.0	0238.2
12:00:26	0	0	0983.4	0054.5	0155.6	0237.2	0236.6	0238.2
12:00:27	0	0	0983.7	0054.5	0155.6	0237.4	0235.2	0238.2
12:00:28	0	0	0983.7	0054.5	0155.8	0237.4	0236.0	0238.4
12:00:29	0	0	0983.4	0054.5	0155.6	0237.4	0236.2	0238.2
12:00:30	0	0	0983.7	0054.5	0155.1	0237.2	0236.2	0238.2
12:00:31	0	0	0984.0	0054.5	0155.6	0237.6	0236.2	0238.4
12:00:32	0	0	0984.0	0054.5	0155.6	0237.4	0236.0	0238.4
12:00:33	0	0	0983.7	0054.5	0155.6	0237.4	0236.0	0238.2
12:00:34	0	0	0983.7	0054.5	0155.6	0237.2	0236.6	0238.2
12:00:35	0	0	0983.7	0054.5	0155.6	0237.4	0236.2	0238.4
12:00:36	0	0	0983.7	0054.5	0155.6	0237.4	0236.2	0238.4
12:00:37	0	0	0985.2	0054.5	0155.6	0237.2	0236.6	0238.4
12:00:38	0	0	0984.9	0054.5	0155.1	0236.8	0236.0	0238.4
12:00:39	0	0	0984.6	0054.5	0155.6	0236.4	0236.4	0239.0
12:00:40	0	0	0984.9	0054.5	0155.6	0237.4	0236.4	0238.4
12:00:41	0	0	0984.9	0054.5	0155.6	0237.8	0236.6	0238.8
12:00:42	0	0	0984.9	0054.5	0155.6	0237.2	0236.2	0238.2
12:00:43	0	0	0984.3	0054.5	0155.6	0237.2	0236.2	0238.2
12:00:44	0	0	0984.6	0054.5	0155.6	0236.4	0236.6	0238.4
12:00:45	0	0	0984.9	0054.5	0155.6	0237.4	0236.4	0238.2
12:00:46	0	0	0985.4	0054.5	0155.6	0236.8	0236.4	0237.8
12:00:47	0	0	0985.7	0054.5	0155.6	0237.4	0236.6	0238.6
12:00:48	0	0	0985.4	0054.5	0155.6	0237.4	0236.6	0238.4
12:00:49	0	0	0985.4	0054.5	0155.6	0237.4	0236.2	0238.4
12:00:50	0	0	0985.2	0054.5	0155.6	0237.6	0236.6	0238.8
12:00:51	0	0	0985.2	0055.0	0155.1	0237.4	0236.2	0238.2
12:00:52	0	0	0985.4	0055.0	0155.6	0237.4	0236.0	0238.4
12:00:53	0	0	0985.7	0055.0	0155.6	0237.0	0236.0	0238.2

PRINT 06 DESCRIPTION - WEATHER DATA

Print No.	Parameter	Description
06L	MVREF	Reference signal value
06L	AMBTP*	Ambient temperature
06L	WINDSP	Wind speed
06L	WINDIR	Wind direction (0^{o} = North 270^{o} = West)
06L	DEWPT	Dew point temperature
06L	PYRHL1	Pyrheliometer No. 1 (Kendall)
06L	PYRHL2	Pyrheliometer No. 2 (Kendall)
06L	PYRNOM	Pyranometer output
06L	BARPR	Barometric pressure
06L	PYRHL4***	Local Eppley pyrheliometer reading
06R	PYRHL3	Pyrheliometer No. 3 (Eppley)
06R	QCALC****	Correlation for input power based on thermocouple readings; ((RCSTP1-RCSTP2) X factor)

*Repeated from Print 5R

**Repeated from Print 01L and 05R

***Repeated from Print 01L; same as PM1

****Not Calibrated for TBC; results for these tests are invalid

TABLE B-6. PRINTOUT OF 06 FOR RUN 13

FACC SMALL COMMUNITY SOLAR EXPERIMENT
DATE: 03/03/82

PRINT: 06L

PAGE: 0001

TIME	RLS	WLS	MVREF PERCENT	AMBTP DEG F	WINDSP MPH	WINDIR DEGS	DEWPT DEG F	PYRHL1 W/M*M	PYRHL2 W/M*M	PYRNOM W/M*M	BARPR IN OF HG	PYRHL4 W/M*M
12:00:00	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.8
12:00:01	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.5
12:00:02	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.8
12:00:03	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.8
12:00:04	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.8
12:00:05	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.5
12:00:06	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.5
12:00:07	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.8
12:00:08	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.4
12:00:09	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.1
12:00:10	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.4
12:00:11	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.8
12:00:12	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.8
12:00:13	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.5
12:00:14	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.1
12:00:15	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.5
12:00:16	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.8
12:00:17	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.8
12:00:18	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.1
12:00:19	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.8
12:00:20	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.8
12:00:21	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.3	0982.8
12:00:22	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.1
12:00:23	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0982.8
12:00:24	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.1
12:00:25	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.1
12:00:26	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.4
12:00:27	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.7
12:00:28	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.7
12:00:29	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.4
12:00:30	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.7
12:00:31	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0984.0
12:00:32	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0984.0
12:00:33	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.7
12:00:34	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.7
12:00:35	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.7
12:00:36	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0983.7
12:00:37	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0985.2
12:00:38	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0984.9
12:00:39	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0984.6
12:00:40	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0984.9
12:00:41	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0984.9
12:00:42	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0984.9
12:00:43	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0984.3
12:00:44	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0984.6
12:00:45	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0984.9
12:00:46	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0985.4
12:00:47	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0985.7
12:00:48	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0985.4
12:00:49	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0985.4
12:00:50	0	0	0099.9	0054.5	0008.6	0228.4	0019.2	0995.0	1006.0	0853.0	0027.5	0985.2
12:00:51	0	0	0099.9	0055.0	0007.9	0246.2	0019.2	0995.0	1005.0	0852.0	0027.5	0985.2
12:00:52	0	0	0099.9	0055.0	0007.9	0246.2	0019.2	0995.0	1005.0	0852.0	0027.5	0985.4
12:00:53	0	0	0099.9	0055.0	0007.9	0246.2	0019.2	0995.0	1005.0	0852.0	0027.5	0985.7

TABLE B-6. PRINTOUT OF 06 FOR RUN 13 (Continued)

FACC SMALL COMMUNITY SOLAR EXPERIMENT
DATE: 03/03/82

PRINT: 06R

TIME	RLS	WLS	PYRHL3 W/M*M	QCALC * KW
12:00:00	0	0	0985.5	0050.3
12:00:01	0	0	0985.5	0038.4
12:00:02	0	0	0985.5	0047.3
12:00:03	0	0	0985.5	0041.4
12:00:04	0	0	0985.5	0048.8
12:00:05	0	0	0985.5	0045.8
12:00:06	0	0	0985.5	0045.8
12:00:07	0	0	0985.5	0047.3
12:00:08	0	0	0985.5	0039.9
12:00:09	0	0	0985.5	0041.4
12:00:10	0	0	0985.5	0039.9
12:00:11	0	0	0985.5	0039.9
12:00:12	0	0	0985.5	0047.3
12:00:13	0	0	0985.5	0039.9
12:00:14	0	0	0985.5	0041.4
12:00:15	0	0	0985.5	0044.4
12:00:16	0	0	0985.5	0039.9
12:00:17	0	0	0985.5	0039.9
12:00:18	0	0	0985.5	0047.3
12:00:19	0	0	0985.5	0048.8
12:00:20	0	0	0985.5	0042.9
12:00:21	0	0	0985.5	0042.9
12:00:22	0	0	0985.5	0038.4
12:00:23	0	0	0985.5	0047.3
12:00:24	0	0	0985.5	0047.3
12:00:25	0	0	0985.5	0039.9
12:00:26	0	0	0985.5	0045.8
12:00:27	0	0	0985.5	0048.8
12:00:28	0	0	0985.5	0034.0
12:00:29	0	0	0985.5	0045.8
12:00:30	0	0	0985.5	0044.4
12:00:31	0	0	0985.5	0047.3
12:00:32	0	0	0985.5	0045.8
12:00:33	0	0	0985.5	0047.3
12:00:34	0	0	0985.5	0047.3
12:00:35	0	0	0985.5	0045.8
12:00:36	0	0	0985.5	0042.9
12:00:37	0	0	0985.5	0039.9
12:00:38	0	0	0985.5	0039.9
12:00:39	0	0	0985.5	0048.8
12:00:40	0	0	0985.5	0034.0
12:00:41	0	0	0985.5	0048.8
12:00:42	0	0	0985.5	0045.8
12:00:43	0	0	0985.5	0037.0
12:00:44	0	0	0985.5	0041.4
12:00:45	0	0	0985.5	0041.4
12:00:46	0	0	0985.5	0047.3
12:00:47	0	0	0985.5	0045.8
12:00:48	0	0	0985.5	0044.4
12:00:49	0	0	0985.5	0048.8
12:00:50	0	0	0985.5	0048.8
12:00:51	0	0	0982.9	0045.8
12:00:52	0	0	0962.9	0044.4
12:00:53	0	0	0982.9	0044.4

PRINT 08 DESCRIPTION - PCS PERFORMANCE DATA

Print No.	Parameter*	Description
08L	TRINPR	Turbine inlet pressure
08L	TRINTP	Turbine inlet temperature
08L	RLEXTP	Regenerator liquid exit temperature
08L	SYOTPR	System (feed) pump exit pressure
08L	TREXPR	Turbine exit pressure
08L	TREXTP	Turbine exit temperature
08L	RCOTTP	Receiver fluid outlet temp
08L	RCOTPR	Receiver fluid outlet pressure
08L	PM4	Power available to PCS
08L	PM5	Power out of PCS
08R	CNINTP	Condenser inlet temperature
08R	CNEXTP	Condenser exit temperature
08R	CNEXPR	Condenser exit pressure
08R	RLINTP	Regenerator liquid inlet temperature
08R	SYINPR	System (feed) pump inlet pressure
08R	TRVLP	Vapor valve position
08R	TURPM	Turbine speed
08R	RESLVL	Reservoir fluid level
08R	DSEVT1	RCIA discrete events No. 1
08R	DSEVT2	RCIA discrete events No. 2

*All parameters on this print are repeats, primarily from Prints 02 and 03

TABLE B-7. PRINTOUT OF 08 FOR RUN 13

FACC SMALL COMMUNITY SOLAR EXPERIMENT

PRINT: OBL

DATE: 03/03/82

TIME	RLS	WLS	TRINPR PSIA	TRINTP DEG F	RLEXTP DEG F	SYOTPR PSIA	TREXPR PSIA	TREXTP DEG F	RCOTTP DEG F	RCOTPR PSIA	PM4 KW	PM5 KW
12:00:00	0	0	0410.8	0745.2	0380.4	0527.6	0001.5	0517.6	0750.4	0494.0	0070.8	0016.2
12:00:01	0	0	0416.0	0741.6	0378.4	0528.4	0001.5	0517.6	0750.0	0494.0	0072.2	0016.3
12:00:02	0	0	0410.0	0741.6	0378.4	0528.0	0001.5	0517.6	0750.4	0493.6	0071.2	0016.4
12:00:03	0	0	0410.4	0743.6	0378.8	0528.0	0001.5	0517.6	0750.4	0494.4	0071.1	0016.1
12:00:04	0	0	0409.6	0744.0	0377.6	0527.2	0001.5	0517.6	0750.4	0494.4	0071.0	0016.1
12:00:05	0	0	0413.2	0741.6	0378.4	0528.8	0001.5	0517.6	0750.4	0494.4	0071.8	0016.0
12:00:06	0	0	0410.8	0743.6	0378.4	0528.8	0001.5	0517.6	0750.4	0494.4	0071.1	0016.1
12:00:07	0	0	0410.8	0743.6	0376.8	0528.8	0001.5	0517.6	0749.6	0494.4	0071.2	0016.2
12:00:08	0	0	0410.8	0743.6	0378.0	0528.4	0001.5	0517.6	0750.8	0494.4	0071.2	0016.2
12:00:09	0	0	0411.2	0743.6	0378.8	0528.4	0001.5	0518.0	0749.6	0494.4	0071.2	0016.3
12:00:10	0	0	0414.4	0743.6	0378.8	0529.2	0001.5	0518.0	0750.4	0493.6	0071.8	0016.2
12:00:11	0	0	0412.8	0743.6	0378.4	0528.0	0001.5	0517.6	0748.0	0493.6	0071.2	0016.2
12:00:12	0	0	0417.6	0744.0	0378.4	0528.8	0001.5	0518.0	0750.0	0494.0	0072.3	0016.3
12:00:13	0	0	0411.6	0744.0	0378.4	0528.4	0001.5	0518.0	0750.4	0494.8	0071.3	0016.2
12:00:14	0	0	0410.8	0745.2	0378.4	0528.0	0001.5	0517.6	0750.4	0494.8	0071.1	0016.1
12:00:15	0	0	0410.4	0743.6	0378.4	0528.0	0001.5	0517.6	0750.4	0494.4	0071.1	0016.0
12:00:16	0	0	0409.6	0743.6	0378.4	0528.0	0001.5	0517.2	0750.4	0494.8	0071.0	0016.2
12:00:17	0	0	0414.0	0743.6	0379.2	0527.6	0001.5	0517.6	0750.4	0494.0	0071.8	0016.1
12:00:18	0	0	0410.4	0743.6	0378.4	0528.4	0001.5	0518.0	0750.4	0492.0	0071.2	0016.0
12:00:19	0	0	0410.8	0743.6	0378.4	0527.6	0001.5	0517.6	0750.4	0495.6	0071.1	0016.0
12:00:20	0	0	0402.8	0743.6	0378.4	0527.6	0001.5	0517.6	0750.8	0495.2	0069.7	0016.4
12:00:21	0	0	0415.6	0743.6	0379.2	0528.4	0001.5	0519.6	0750.4	0495.6	0071.9	0016.1
12:00:22	0	0	0410.4	0741.6	0378.4	0527.6	0001.5	0518.0	0750.4	0494.4	0071.2	0016.4
12:00:23	0	0	0414.4	0743.6	0378.4	0529.2	0001.5	0517.6	0750.0	0494.0	0071.8	0016.3
12:00:24	0	0	0410.8	0743.6	0379.6	0528.4	0001.5	0518.0	0749.6	0494.4	0070.9	0016.1
12:00:25	0	0	0415.6	0741.6	0378.4	0528.4	0001.5	0518.0	0750.4	0494.4	0072.1	0016.1
12:00:26	0	0	0410.8	0741.6	0378.0	0528.4	0001.5	0518.4	0750.4	0494.4	0071.3	0016.3
12:00:27	0	0	0406.0	0744.0	0378.4	0527.2	0001.5	0517.6	0750.4	0494.4	0070.4	0016.3
12:00:28	0	0	0412.4	0743.6	0379.2	0528.4	0001.5	0518.0	0750.0	0494.4	0071.3	0016.2
12:00:29	0	0	0410.8	0743.6	0378.4	0528.0	0001.5	0517.6	0749.6	0494.4	0071.0	0016.4
12:00:30	0	0	0406.0	0740.8	0376.8	0527.2	0001.5	0518.0	0750.0	0495.6	0070.6	0016.2
12:00:31	0	0	0410.8	0741.6	0378.4	0528.0	0001.5	0518.0	0750.4	0494.4	0071.2	0016.2
12:00:32	0	0	0412.8	0741.6	0379.6	0528.8	0001.5	0518.0	0750.0	0494.8	0071.4	0016.1
12:00:33	0	0	0409.2	0743.6	0379.2	0528.4	0001.5	0518.0	0750.4	0494.8	0070.9	0016.1
12:00:34	0	0	0410.8	0741.6	0379.2	0528.4	0001.5	0518.4	0750.0	0494.8	0071.1	0016.2
12:00:35	0	0	0410.8	0741.6	0378.4	0528.8	0001.5	0518.0	0750.0	0494.4	0071.2	0016.4
12:00:36	0	0	0418.8	0741.6	0379.2	0528.8	0001.5	0518.0	0749.6	0493.6	0072.5	0016.0
12:00:37	0	0	0415.6	0741.6	0379.2	0529.2	0001.5	0516.8	0749.6	0494.4	0071.9	0016.1
12:00:38	0	0	0412.4	0743.6	0379.2	0527.6	0001.5	0518.0	0750.4	0495.6	0071.4	0016.5
12:00:39	0	0	0410.8	0743.6	0378.4	0528.8	0001.5	0517.6	0750.0	0494.8	0071.1	0016.8
12:00:40	0	0	0418.0	0741.6	0378.4	0528.8	0001.5	0518.0	0749.6	0494.4	0072.5	0016.1
12:00:41	0	0	0419.6	0743.6	0379.2	0528.8	0001.5	0518.0	0750.0	0493.6	0072.6	0016.3
12:00:42	0	0	0412.4	0743.6	0378.4	0527.6	0001.5	0518.0	0749.6	0494.0	0071.4	0016.7
12:00:43	0	0	0412.4	0743.6	0379.2	0527.6	0001.5	0518.0	0750.0	0494.4	0071.3	0016.2
12:00:44	0	0	0415.6	0741.6	0379.2	0527.6	0001.5	0518.4	0749.6	0494.0	0071.9	0015.9
12:00:45	0	0	0410.8	0743.6	0379.2	0529.2	0001.5	0518.0	0750.0	0494.8	0071.0	0016.7
12:00:46	0	0	0406.8	0743.6	0378.4	0527.6	0001.5	0518.0	0749.6	0492.0	0070.3	0016.4
12:00:47	0	0	0413.6	0741.6	0379.6	0527.6	0001.5	0517.6	0749.6	0494.0	0071.5	0016.0
12:00:48	0	0	0413.2	0743.6	0378.4	0528.4	0001.5	0517.6	0749.6	0494.[illegible]	0071.6	0017.0
12:00:49	0	0	0411.2	0743.6	0378.4	0528.4	0001.5	0518.0	0749.6	0492.4	0071.2	0016.3
12:00:50	0	0	0418.8	0743.6	0379.2	0528.0	0001.5	0517.6	0749.6	0493.6	0072.4	0016.0
12:00:51	0	0	0410.8	0741.6	0379.2	0529.2	0001.5	0518.0	0751.6	0493.2	0071.3	0015.7
12:00:52	0	0	0409.6	0741.6	0378.4	0527.6	0001.5	0518.0	0749.2	0494.8	0070.9	0016.0
12:00:53	0	0	0406.0	0740.8	0378.4	0528.0	0001.5	0518.0	0749.6	0494.8	0070.4	0016.0

TABLE B-7. PRINTOUT OF 08 FOR RUN 13 (Continued)

FACC SMALL COMMUNITY SOLAR EXPERIMENT

PRINT: OBR DATE: 03/03/82 PAGE: 0001

TIME	RLS	WLS	CNINTP DEG F	CNEXTP DEG F	CNEXPR PSIA	RLINTP DEG F	SYINPR PSIA	TRVLP PERCENT	TURPM KRPM	RESLVL PERCENT	DSEVT1 EVENTS	DSEVT2 EVENTS
12:00:00	0	0	0172.9	0082.8	0001.1	0091.6	0027.8	0047.3	0047.6	0078.2	00000110	01011100
12:00:01	0	0	0172.6	0082.8	0001.1	0091.7	0027.4	0047.7	0047.6	0078.0	00000110	01011100
12:00:02	0	0	0173.0	0082.6	0001.1	0091.7	0027.8	0047.2	0047.6	0078.3	00000110	01011100
12:00:03	0	0	0173.0	0082.7	0001.1	0091.7	0027.7	0047.4	0047.6	0078.3	00000110	01011100
12:00:04	0	0	0173.0	0082.6	0001.1	0091.7	0027.8	0047.4	0047.6	0078.1	00000110	01011100
12:00:05	0	0	0173.0	0082.7	0001.1	0091.7	0027.4	0047.4	0047.6	0077.7	00000110	01011100
12:00:06	0	0	0173.2	0082.6	0001.1	0091.4	0027.6	0047.4	0047.6	0078.1	00000110	01011100
12:00:07	0	0	0173.2	0082.6	0001.1	0091.7	0027.7	0047.2	0047.6	0078.3	00000110	01011100
12:00:08	0	0	0173.2	0082.6	0001.1	0091.5	0027.8	0047.3	0047.6	0077.8	00000110	01011100
12:00:09	0	0	0173.0	0082.6	0001.1	0091.5	0027.5	0047.3	0047.6	0077.0	00000110	01011100
12:00:10	0	0	0173.5	0082.6	0001.1	0091.5	0027.5	0047.6	0047.6	0077.4	00000110	01011100
12:00:11	0	0	0173.0	0082.5	0001.1	0091.4	0027.6	0047.4	0047.6	0077.7	00000110	01011100
12:00:12	0	0	0173.1	0082.5	0001.1	0091.4	0027.7	0047.7	0047.8	0077.7	00000110	01011100
12:00:13	0	0	0173.2	0082.4	0001.1	0091.0	0027.9	0047.4	0047.6	0077.4	00000110	01011100
12:00:14	0	0	0173.2	0082.4	0001.1	0091.4	0027.7	0047.4	0047.6	0076.7	00000110	01011100
12:00:15	0	0	0173.4	0082.5	0001.1	0091.5	0027.8	0047.4	0047.6	0077.4	00000110	01011100
12:00:16	0	0	0173.4	0082.7	0001.1	0091.3	0027.8	0047.3	0047.6	0077.7	00000110	01011100
12:00:17	0	0	0173.3	0082.4	0001.1	0091.4	0027.7	0047.6	0047.6	0077.0	00000110	01011100
12:00:18	0	0	0173.2	0082.2	0001.1	0091.3	0027.8	0047.4	0047.8	0077.0	00000110	01011100
12:00:19	0	0	0173.3	0082.3	0001.1	0091.3	0027.8	0047.4	0047.6	0077.5	00000110	01011100
12:00:20	0	0	0173.5	0082.3	0001.1	0091.2	0028.0	0046.6	0047.4	0077.8	00000110	01011100
12:00:21	0	0	0173.4	0082.3	0001.1	0091.3	0027.7	0047.6	0047.8	0077.1	00000110	01011100
12:00:22	0	0	0173.5	0082.1	0001.1	0091.2	0027.8	0047.4	0047.6	0078.0	00000110	01011100
12:00:23	0	0	0173.6	0082.1	0001.1	0091.1	0027.6	0047.6	0047.6	0078.8	00000110	01011100
12:00:24	0	0	0173.7	0082.2	0001.1	0091.1	0027.6	0047.3	0047.6	0077.3	00000110	01011100
12:00:25	0	0	0173.9	0082.3	0001.1	0091.0	0027.8	0047.6	0047.6	0077.1	00000110	01011100
12:00:26	0	0	0174.2	0082.1	0001.1	0091.0	0027.8	0047.4	0047.6	0077.5	00000110	01011100
12:00:27	0	0	0173.8	0082.1	0001.1	0091.0	0027.8	0047.1	0047.6	0077.2	00000110	01011100
12:00:28	0	0	0174.0	0082.0	0001.1	0091.0	0027.7	0047.4	0047.8	0077.2	00000110	01011100
12:00:29	0	0	0173.8	0082.1	0001.1	0091.0	0027.7	0047.3	0047.6	0077.3	00000110	01011100
12:00:30	0	0	0173.6	0082.1	0001.1	0091.1	0027.8	0047.0	0047.6	0077.1	00000110	01011100
12:00:31	0	0	0173.5	0082.1	0001.1	0090.9	0027.7	0047.4	0047.6	0077.3	00000110	01011100
12:00:32	0	0	0173.5	0082.1	0001.1	0091.1	0027.9	0047.6	0047.6	0077.4	00000110	01011100
12:00:33	0	0	0173.4	0082.0	0001.1	0090.9	0027.8	0047.2	0047.6	0077.0	00000110	01011100
12:00:34	0	0	0173.4	0082.3	0001.1	0090.9	0027.7	0047.4	0047.6	0076.9	00000110	01011100
12:00:35	0	0	0173.3	0081.9	0001.1	0090.8	0027.9	0047.4	0047.6	0077.0	00000110	01011100
12:00:36	0	0	0173.4	0081.[illegible]	0001.1	0090.9	0027.6	0048.0	0047.8	0077.8	00000110	01011100
12:00:37	0	0	0173.5	0082.0	0001.1	0090.7	0027.6	0047.4	0047.6	0077.7	00000110	01011100
12:00:38	0	0	0173.5	0081.9	0001.1	0090.9	0027.8	0047.4	0047.6	0077.0	00000110	01011100
12:00:39	0	0	0173.3	0081.9	0001.1	0090.8	0027.7	0047.4	0047.6	0077.1	00000110	01011100
12:00:40	0	0	0173.3	0081.9	0001.1	0090.7	0027.5	0047.7	0047.8	0077.2	00000110	01011100
12:00:41	0	0	0173.5	0081.8	0001.1	0090.8	0027.3	0047.8	0047.8	0077.0	00000110	01011100
12:00:42	0	0	0173.6	0082.3	0001.1	0090.6	0028.0	0047.4	0047.6	0077.4	00000110	01011100
12:00:43	0	0	0173.5	0081.8	0001.1	0090.7	0027.8	0047.6	0047.6	0077.7	00000110	01011100
12:00:44	0-	0	0173.5	0081.8	0001.1	0090.6	0027.5	0047.4	0047.6	0076.7	00000110	01011100
12:00:45	0	0	0173.6	0082.0	0001.1	0090.9	0027.7	0047.4	0047.6	0077.0	00000110	01011100
12:00:46	0	0	0173.5	0081.8	0001.1	0090.6	0027.9	0047.0	0047.6	0077.5	00000110	01011100
12:00:47	0	0	0173.5	0081.6	0001.1	0090.7	0027.4	0047.4	0047.6	0076.9	00000110	01011100
12:00:48	0	0	0173.3	0081.8	0001.1	0090.6	0027.5	0047.4	0047.8	0076.9	00000110	01011100
12:00:49	0	0	0172.6	0081.8	0001.1	0090.5	0027.5	0047.3	0047.6	0076.6	00000110	01011100
12:00:50	0	0	0174.3	0081.9	0001.1	0090.5	0027.3	0047.7	0047.6	0077.1	00000110	01011100
12:00:51	0	0	0172.9	0081.8	0001.1	0090.5	0027.7	0047.4	0047.6	0077.2	00000110	01011100
12:00:52	0	0	0173.0	0081.4	0001.1	0090.2	0027.9	0047.2	0047.6	0077.0	00000110	01011100
12:00:53	0	0	0173.1	0081.8	0001.1	0090.5	0027.9	0047.0	0047.6	0077.1	00000110	01011100

SCSE:AppB:15